THE ABCs OF DCs
DISTRIBUTION CENTER MANAGEMENT: A BEST PRACTICES OVERVIEW

A REPORT BY THE SUPPLY CHAIN MANAGEMENT FACULTY
AT THE UNIVERSITY OF TENNESSEE

FEBRUARY 2015
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THE ABCs OF DCs

DISTRIBUTION CENTER MANAGEMENT: A BEST PRACTICES OVERVIEW

THE FIFTH IN THE GAME CHANGERS SERIES OF UNIVERSITY OF TENNESSEE SUPPLY CHAIN MANAGEMENT WHITE PAPERS

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The Game-Changers Series of University of Tennessee Supply Chain Management White Papers

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Introduction

Logistics professionals who operate distribution centers (DCs) have a tough job. Management constantly challenges them to cut cost, which means doing more with less. While focused on that, they need to make sure that customer responsiveness does not suffer and even improves. Clearly this calls for a highly advanced management skill set.

This white paper draws on data from three sources. The first is information gleaned from the supply chain audits done at the University of Tennessee. The second is from third party logistics professionals who manage extremely large warehouse networks for very demanding clients. Finally, the third set of inputs was drawn from industry supply chain professionals with extensive warehouse management responsibilities. The companies included some of the largest retailers in the world, prominent manufacturers, and 3PLs.

Eleven themes emerged from this research and are covered in the white paper:

1. Receiving
2. Picking/Order Fulfillment/Shipping
3. Lean Warehousing
4. Cross-Docking
5. Metrics and Planning
6. Warehouse Information Systems
7. Warehouse Layout and Space Optimization
8. Warehouse Network Optimization
9. Safety and Security
10. People
11. Sustainability

For each theme, we include a short discussion of best practices for supply chain professionals to consider as they develop a DC management strategic plan. Clearly DCs come in many shapes and sizes, from case picking to individual item, highly automated to mainly manual, small in square footage to just plain huge. To cover this scope in one white paper is daunting, but the best practices described below are intended to apply to the broadest possible range of DC types.
Receiving and Put Away

All warehouses need an efficient process to receive and put away or cross dock goods. (Cross docking is discussed in its own section later.) The receiving and put-away processes critically affect overall warehouse efficiency.

Receiving

At the most basic level, vendors that ship into distribution centers need to be reliable. Suppliers must be certified so that quality and accuracy are assured. Inspection and count verification required at the DC should be minimal. Suppliers should also have the capability of sending advanced shipment notices (ASNs) before their shipments arrive.

World-class receiving is highly facilitated by the use of advanced shipment notices. An ASN notifies the DC of a pending delivery and is usually sent in an electronic data interchange transmission. Suppliers use ASNs to list the contents of a shipment as well as additional detailed information describing the shipment’s composition and configuration. By receiving the ASN before delivery, receiving cost can be reduced and accuracy improved. Advanced shipment notices make labor planning much easier since DCs know what will be hitting their docks before it gets there. It should be noted that many manufacturing companies receive product from their own factories to their own DCs. In that case, the internal systems can be linked, accomplishing the same thing as an ASN.
Advanced shipment notices eliminate most data entry, and data entry errors, at the time of receiving. Distribution centers receiving operations can do quick scans of barcodes on shipping labels and electronically match them to the ASN information. Generally an ASN provides a list of all the barcoded identification numbers of the shipment contents. This improves inventory accuracy and greatly reduces receiving costs. Cost reduction estimates are in the 40–50 percent range.

In addition, the advanced shipping notice can be used to pay suppliers directly for goods received by inputting the notice into the company’s enterprise resource planning system, which includes the accounts payable system. Any discrepancies can be quickly transmitted to the supplier and corrected, so payment can be executed in a timely manner.

The use of advance shipment notices is clearly a best practice. ASNs have been around for decades and one would think they would be nearly ubiquitous by now. Unfortunately, that is far from true. Progress is being made, but shockingly some of the largest and most prominent companies still have not fully implemented ASN technology in their finished goods distribution centers. One major retailer told us that 30 percent of their inbound shipments had an ASN, with the major constraint being the capability of their suppliers. Another major retailer said that their suppliers could provide ASNs, but their internal systems could not handle them. ASN technology is far more common in factory operations for the receipt of raw material and less common in finished goods DCs.

**Put Away**

A modern warehouse management system should provide exact direction for put away. Goods should be placed in the best locations to facilitate picking (see profiling/slotting discussion later), and they should be placed in warehouse locations to minimize the travel distance and time of distribution center personnel.

Best practice distribution centers put away product quickly. Companies should measure “dock to stock” time to help facilitate this process. Slow put away negatively affects space, causes congestion, increases transaction errors, and makes product more susceptible to damage. The most efficient DCs move product directly from receipt to the final location. Direct put-away programs require a good warehouse management system that can assign locations from an advanced shipping notice or upon receipt to the dock.

Best practice companies also use integrated engineering standards in their warehouse management system (WMS) and pick locations and replenishment areas so that an optimal put-away route from receiving to storage areas can be selected. Many WMS programs also support task interleaving so that put-away and picking operations can be performed in tandem to greatly reduce nonproductive travel time.
Returns

Returned products need to be received as well. With the panindustry race to make returns easier and more customer friendly, as well as the increase in Internet sales, DCs can expect returns to increase substantially. Of course, many supply chain professionals believe that the best practice is to eliminate returns or at least returns back to the DC. This is generally done by offering a return allowance in order to incentivize the retailer to deal with returns. Alternatively, some firms farm out handling returns to a company that specializes in it, like Inmar. Other companies feel that the customer relations risk requires returns to be handled in-house. Ironically in many such cases, returns are often treated as an afterthought and managed in a highly disorganized way. When it comes to managing returns, many companies leave a lot of money on the table. A little attention here can pay big dividends.

A recommended process for managing returns

- **Identify** root causes of returns.
- **Measure** the full cost of returns, which most companies grossly underestimate.
- **Review** product design, packing, and consumer instructions.
- **Manage** better customer education and expectations on the front end of the purchase.
- **Segment** returns with a different approach for each category.
- **Develop** an operations plan to minimize the processing cost.
- **Put in place** a liquidation plan to maximize asset recovery; a decision tree framework is often useful.
A ggressive distribution center productivity goals cannot be met without an efficient process for picking or order fulfillment. In fact, picking often consumes the lion’s share of DC labor. Based on our statistics, warehouse labor is consumed in the following manner:

![Picking/Order Fulfillment/Shipping](image)

To optimize warehouse efficiency, the DC needs to focus on and minimize three things: travel distance, touches, and paper. The best picking systems have low rates of each. Of course reducing travel distance is critical, and creativity is helpful. For example, one company told us that it installed forty-five degree aisles in their distribution center and saved a major amount of time by traveling the hypotenuse.

In our discussions with supply chain professionals, we saw a wide variety of ways companies fill orders efficiently. Of course many small DCs have not abandoned paper pick lists. But whether done with paper or with the technologies described below, a key to efficient picking is proper profiling or slotting.

Warehouse space optimization and layout closely relate to profiling, and they are also fundamental to an efficient picking operation. We discuss this theme in its own section later in the white paper.

**Profiling/Slotting (Zoning or ABC Zoning)**

It goes by various names, but regardless of the moniker, it’s a prerequisite to efficient fulfillment operations. Many DCs dedicate full-time personnel to the task of profiling or slotting. Their job is to ensure that high velocity SKUs are placed in convenient, easy to reach areas to minimize pick times. They do this by studying the velocity of each SKU stored in the DC, often with the assistance of their warehouse management systems. Studies have shown that travel time is three times more impactful than search and selection time, although both are important and both are facilitated by a good profiling system. Warehouse layout and picking are closely connected; in fact, a primary goal of warehouse layout is to facilitate picking.
Profilers know that it costs more to pick vertically above the floor than horizontally on the floor. So the fastest moving items are assigned to floor level. Hot zones are set up for fast moving SKUs to increase picking productivity. High cube items are often assigned to racks, while low cube, smaller items are assigned to bins or shelves.

We saw a good example of a profiling operation at an office supplies retailer’s distribution center. They dedicated three people to ensuring that the right SKUs are in the right places. They use a feature in their warehouse management system to assist in this effort. Others use special slotting or profiling software. Such software can be configured to physically separate error-prone items where pickers tend to mix items if slotted too close together. A cosmetics manufacturer has five rows of items in its pick area. It puts the highest volume lipstick in row three at eye level, but separates similar colors to avoid pick errors. An appliance manufacturer calls their version of profiling “ABC banding,” which ensures that they put the highest volume appliance SKUs closest to the outbound truck docks.

As noted, profiling should be done on a dynamic basis with the aid of the warehouse management system. There should be no permanent locations, given the frequent changes. One caveat: fast moving items should be easy and fast to pick. But they may have to be spread out to minimize congestion problems.

### Picking Systems

One of our recent surveys found that firms used the following types of picking systems.

- Radio frequency vehicle mount - 80%
- Paper pick list - 40%
- Pick to light - 38%
- Carousels/conveyor systems - 25%
- Voice picking - 5%
- A frame - 5%
- Automated storage and retrieval systems - 5%
- KIVA - 1%
- Other - 22%

### Voice Picking

Some call this the greatest gain in picking in the past twenty-five years, while others are much more subdued in their enthusiasm. With voice picking, operators wear a small portable computer with a headset incorporating a microphone. They receive verbal commands via the headset and confirm actions though the microphone to the warehouse management system.
When it comes to accuracy, voice picking wins, because the operator reads a check digit back to the computer to confirm the right pick was made. Error rates of less than one per thousand picks have been reported. Other picking technologies are accurate, but if you go from 99 percent accuracy with one method to 99.9 percent accurate with voice, you avoid 9,000 errors per million picks. This can clearly be significant for some products and customers.

Voice systems can speed up the learning curve for new warehouse employees as well. One firm told us that the time between on-boarding and full efficiency went from five weeks to five days when they converted to a voice system.

Installing a voice-picking system requires a significant investment, perhaps $5,000 per unit. So voice picking is most appropriate in a larger facility with a significant number of people. To generate a high enough ROI on those sunk costs, a rule of thumb would be forty to fifty workers using the system.

Voice picking is hands-free and therefore also contributes to safety. It can employ multiple languages within the same warehouse, which is beneficial to US operations in areas with a high Spanish language population. Having native language capability can clearly enhance operator productivity. The voice speed in the headset can also be set very fast as operators become accustomed. Although high-speed voice seems incomprehensible to rookies, highly experienced operators quickly adjust to it.

**PICK TO LIGHT**

With pick to light, stock locations have light nodes connected to the main computer system. These light up indicating which units to pick. When the associate completes the pick, he or she presses a button next to the light to confirm it.

If applied in the right setting, pick-to-light systems are faster but not as accurate as voice. For small items, especially in small slots, someone could touch the light but reach into the wrong slot. This can happen an estimated three times in every 1,000 picks—at least three times higher than voice picking. Weight check systems at the end of the pick can help catch such errors.

Of course, speed depends on the right application. Pick to light works best for small, relatively fast-moving items where a picker can simultaneously see all items to be picked for an order, rather than be given instructions sequentially. It is not as useful for case picking or picking a wide range of larger product sizes/weights. Pick-to-light systems can require expensive conveyors, challenging their ROI.

**RADIO FREQUENCY**

In wireless radio frequency picking environments, the associate generally has a radio frequency gun that can be holstered. Radio frequency/scanning is highly accurate but not perfect. Sometimes an operator can take his or her eyes off the picking location when the scanner is being returned to the holster. Items
and pallets are scanned, and that is matched to a scanned location to enhance accuracy. Voice and pick-to-light systems are more productive and more accurate than radio frequency. Radio frequency pickers spend an estimated 15 percent of their time manipulating the radio frequency gun.

**AUTOMATED PICKING**

(A-frame or automated storage and retrieval systems)

A-frame picking systems have bins or totes that flow on a conveyor through a stocked A-frame. Based on the bar code, the right units fall into the tote as it passes under the A-frame. A-frames are generally used for small items.

Automated storage and retrieval systems can be several stories tall and totally automated. A robot-like device moves through the high-rise warehouse picking the appropriate units from the warehousing racks.

Automated systems require a major capital investment. So without a long contract in place, 3PLs find these systems are problematic.

**GOODS-TO-PERSON PICKING (KIVA)**

With KIVA, a wholly owned subsidiary of Amazon, robots bring the product to the person assembling the order. A rule of thumb is that at least 50 percent of picking time is operator travel time, often much more. These systems eliminate operator travel time. A number of companies other than KIVA now offer goods-to-person robotic systems. These are expensive. An operation would have to be a large, high volume facility often involved in “each” picking—picking individual units, not cartons—for this technology to pay off.

**ROBOTICS AND AGVs**

Robotics are becoming more feasible as technology advances; they can do basic picking and other operations. For example, hourly associates can easily program Baxter robots from ReThink Robotics. They are relatively low cost at about $25,000. And, if they can replace a full-time employee, the ROI should be quick.

Automated guided vehicles (AGVs) are another form of robotics. In the original models, the units followed a wire embedded in the floor. Newer AGVs can be laser guided. Mirrors and laser beams continuously tell the vehicle where it is. Some newer AGVs accomplish this with location bar codes around the DC, along with a camera/optical recognition system.

**MANUAL/PAPER BASED SYSTEMS**

These are the least accurate and the least productive systems. But a paper-based system may make perfect sense for many small operations, and there are thousands of very small warehouse operations employing ten people or fewer.
Postponement Operations

Picking and order fulfillment will be heavily impacted by the trend toward postponement. More and more orders will be kitted, packaged, given unique identifiers like branding and literature, or lightly assembled. These capabilities are driven by the vision of a low inventory, flow through environment, and they will become increasingly common in the future e-fulfillment world. In both postponement and other DC activities, packaging must be optimized to reduce the waste, weight, and cube.

How to Select the Right Picking System

When deciding which picking technology to employ, several factors come into play. Three of the most important are operating cost, accuracy, and capital investment. Safety should also be considered along with product damage potential. When calculating the ROI of various options, it is important to put a number on hard-to-quantify items like safety or picking accuracy. Otherwise, they tend to become nonfactors in the decision when in fact they may be among the most important considerations.

To narrow options prior to doing an in-depth ROI analysis on the most viable alternatives, create a matrix like the following and rate each cell:

<table>
<thead>
<tr>
<th>Decision criteria</th>
<th>Decision criteria weighting</th>
<th>Picking System A</th>
<th>Picking System B</th>
<th>Picking System C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating cost/productivity</td>
<td>Weight</td>
<td>Ranking</td>
<td>Ranking</td>
<td>Ranking</td>
</tr>
<tr>
<td>Capital investment</td>
<td>Weight</td>
<td>Ranking</td>
<td>Ranking</td>
<td>Ranking</td>
</tr>
<tr>
<td>Integration with other systems</td>
<td>Weight</td>
<td>Ranking</td>
<td>Ranking</td>
<td>Ranking</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Weight</td>
<td>Ranking</td>
<td>Ranking</td>
<td>Ranking</td>
</tr>
<tr>
<td>Safety</td>
<td>Weight</td>
<td>Ranking</td>
<td>Ranking</td>
<td>Ranking</td>
</tr>
<tr>
<td>Damage</td>
<td>Weight</td>
<td>Ranking</td>
<td>Ranking</td>
<td>Ranking</td>
</tr>
</tbody>
</table>

Note that the table above has a column labeled “Decision Criteria Weighting.” This forces the selection team to make hard decisions regarding their most important needs in a picking system.

Once the options are narrowed to perhaps two or three picking systems using the ranking process above, it’s time to gather hard data from vendors, probably through an RFP process. After the cost/investment and benefits are accurately quantified, an accurate ROI for each option can be calculated and the selection made.
Omnichannel Picking

Omnichannel fulfillment—from Internet and mobile phones sources—is becoming increasingly common for manufacturers and retailers. The rise of the omni-channel means that DCs can no longer batch all of their orders into large waves that must be completely processed before taking on the next wave of orders. Internet orders are filled in a waveless picking process. They have to be filled very quickly, perhaps within a couple of hours, and often result in difficult piece picking, exacerbated by seasonal spikes. It is further burdened by a large number of SKUs and creates the need for increased inventory control, flexibility, and fast, accurate fulfillment.

Instead of one large order to pick for a store or another warehouse, distribution centers will have to ship hundreds of small orders to individuals all over the country. Warehouse operators will have to become increasingly flexible in their pick, pack, and ship operations. Speed, efficiency, and accuracy will be required as never before. No doubt, creative automation approaches will emerge. More and more large retailers are filling Internet orders out of retailstore locations as well as their DCs. Software exists which determines the optimal ships from location. The customer can get home delivery for an additional charge, or pick up the order up at the store location.

Some retailers are partnering with services like Google Express to fulfill their Internet orders. Google Shopping Express is a same-day shopping service that was launched on a free, trial basis in San Francisco and Silicon Valley in spring 2013 and publicly in September that year. In spring 2014 it was expanded to New York and Los Angeles, and in fall 2014 to Chicago, Boston, and Washington, DC. Google does not have any physical infrastructure, and instead sends shoppers into existing stores.
Lean Warehousing

Lean concepts originated in the 1950s in Japan and developed and matured in Toyota factories over several decades. The Lean philosophy first reached the shores of the United States in the 1980s with a few pioneering companies like John Deere and Harley Davidson. Then it exploded into US manufacturing in the 1990s. From there, Lean concepts escaped the confines of the factory. The Lean philosophy is now being used throughout the supply chain, especially in warehouse operations.

Many firms, both retailers and manufacturers, are now aggressively rolling out Lean in their warehouse operations. In the process they reduce cycle times, speed up customer responsiveness, and reduce waste throughout their operations. Huge paybacks are being seen with Lean implementations in one warehouse operation after another. It is safe to say that if a warehouse operation is not implementing Lean, it is falling behind its competition.

Many companies have their versions of Lean that closely follow its fundamental principles, such as the Kenco Operating System or the Honeywell Operating System. If the 3PL is running the DC operation, they will need to take the first steps toward implementing Lean in the facility. Some examples of Lean concepts commonly used in DCs are discussed below.
**Keep it Simple**

Don’t over complicate this. The Lean journey should focus on straightforward activities that everyone can see and understand. This means concepts like 5S, total employee involvement, standard work, visual management, and management walkabouts. This foundation can then lead to more sophisticated concepts such as value-stream mapping. Lean is a lot about total employee involvement in a continuous improvement effort. So, DCs shouldn’t rush to implement the Lean tools. Sometimes the tools take on a life of their own, causing the operation to lose sight of the simple goal of waste elimination. With that said, some of the tools and concepts of Lean are described below.

**5S**

5S refers to a methodology and mindset that ensures that all areas are neat, clean, with everything in its place. Although it varies, the five S’s usually stand for “sort, set in order, shine, standardize, and sustain.” A number of warehouse operations add a sixth “S” for safety. Few would argue with that. In fact, in most warehouse operations, the warehouse manager is quick to say that safety is the number one priority and objective.

**Total Employee Involvement**

The real secret of Lean is that it creates a learning organization that focuses on continuous improvement or kaizen. Lean takes a full commitment from the top and full involvement from the bottom. One company chose several “lean champions” from among the hourly associates in the DC and asked them to gather improvement ideas from their peers. Those Lean champions also led “5 Why” sessions. In these sessions, the problem is identified, and then the group asks “why” five times to reach its root cause. One firm has a simple form called a SPIN (simplified process improvement needed) form available for the hourly associates to submit their suggestions. They said that this process starts slowly but really takes off when people see their ideas being implemented.

**Standard Work and Making Problems Visible**

Some Lean advocates say that there can be no kaizen without standardization. All work needs to be rigorously documented. That ensures continuity of improvements and makes deviations more visible. The three-step process of “standardize, measure, and improve” has standard work at its root.

Some have used the MOST system with success. The Maynard Operation Sequence Technique—MOST—is a predetermined motion time system that is used primarily in industrial settings to set the standard time in which a worker should perform a task.
Management Walkabouts

Some years ago, management by wondering around was all the rage and for good reason. It worked. Managers need to get up, get out and about, and talk to people face-to-face. It’s the only way to understand the problems and the mood of the organization. It’s important to do this with a set of good questions, such as “Do you see anything we could do better?” or “Is your area ahead or behind schedule?” The millennials especially may need encouragement to give up electronics and talk directly to humans.

Visual Management

Lean warehouse operations are visual operations, designed to promote employee involvement. As one warehouse professional asked, “How can you expect your team to perform if they don’t know the score?” Lean operations visibly place charts and graphs everywhere. Andon lights clearly show the status of mechanical operations. One company mounted a large four by eight foot poster displaying a fishbone diagram that focused on an inventory accuracy problem existing in the warehouse. On the horizontal spine of the diagram was shown the problem, i.e. inventory accuracy. On the diagonal bones of the diagram were listed general areas that could be the source of the problem like systems or human error. All associates were invited to use Post-it notes to comment on various aspects of the problem.

Total Productive Maintenance

With total productive maintenance, associates who work with equipment are also responsible for routine maintenance. This not only promotes employee involvement and ownership but also reduces unexpected downtime. As one associate said, “Who knows more about how your car sounds: you or the mechanic in the shop? It’s the same with the equipment we use every day.”

It’s critical that conveyor systems and automation not break down unexpectedly. Therefore, maintenance technicians should focus on predictive and preventative maintenance, rather than routine maintenance. Routine maintenance should be left to the equipment operators. Maintenance technicians should plan and execute preventative maintenance activities during planned downtime. And they should be using advanced techniques such as vibration analysis and infrared analysis to detect problem areas, as well as hot spots that could predict failure.

Eliminate Before You Automate

Automation is critical to large, efficient warehouse operations, but it can be overdone. One company had an empty automated storage and retrieval system,
calling it the “epitome of a monument to waste.” They had found a way to flow product through the warehouse without putting it in, and pulling it out of the automated storage and retrieval systems. Another company eliminated the need for an automated guided vehicle by simply moving the two material points next to each other. An eliminate before you automate mindset avoids hardwiring waste into an operation.

**Value Stream Mapping**

Value stream mapping helps identify value-added versus non-value-added activities in a process. It is used as a vehicle to eliminate waste. It requires visually mapping a process and then asking a group of employees/associates to identify opportunities for improvement as well as non-value-added activities to eliminate. Value stream mapping can ensure that there is quality at the source and that there are no rework loops. It can be applied to any process and almost never fails to identify savings of at least 20 percent or more, according to the experts we polled. It is critical to include in the value stream the supply chain steps both prior to the warehouse wall and after the warehouse wall. The biggest losses can be in the handoff between supply chain activities.

Much like the fishbone diagram example above, one warehouse created a four-by-eight-foot map of their receiving process. Employees were encouraged to place Post-it notes with their ideas for improvement as a lead in to the value stream mapping exercise.

**Office Operations**

It should be noted that some DCs have applied Lean concepts in their office operations, including standard work, visual management, and value stream mapping. This could encompass anything from office proximity and printer placement to checklists and work in progress boards.

**Six Sigma**

Six Sigma was never part of the Toyota Production System or Lean. It is instead a separate set of tools and philosophies that nicely complement Lean. In fact, many companies call their program Lean/Sigma or something similar. In many companies Six Sigma simply means a measure of quality that strives for near perfection. It is a disciplined, data-driven approach and methodology for eliminating defects and variation in any process. A product of Six Sigma quality has 3.4 defects/variations per million or is consistent 99.9997 percent of the time.

The Six Sigma DMAIC system improvement process includes five steps for processes falling below specification: define, measure, analyze, improve, and control. Six Sigma has a similar methodology for projects in development called DMADV (define, measure, analyze, design, and verify). Six Sigma black belts learn to apply analytical and statistical techniques to business problems. In many companies, they have established a track record of multimillion-dollar savings.
Cross Docking

Cross docking is the process of receiving product and shipping the product out the same day without putting it into storage. Since picking and put away consume the lion’s share of cost in a typical warehouse operation, productivity skyrockets if those two activities can be eliminated. The cross docking practice also frees up warehouse space and speeds service to the customer. Some high volume warehouse operations are designed to cross dock automatically. Wal-Mart DCs receive cartons from suppliers and place them from the inbound truck into a high-speed conveyor system. Many of those cartons continue to flow all the way down to a truck waiting to go to a Wal-Mart supercenter. There is no picking or put away for such items.

However, most warehouse operations don’t have the luxury of super high volume case flow like Wal-Mart. If they do cross dock, they have to do it the old fashioned way: they schedule inbound delivery from their suppliers to coincide with outbound delivery. That’s far easier said than done, and it’s far easier if central control of orders and inventory exists. One retailer told us that they cross dock about 40 percent of their goods using such a centralized system. The corporate group has visibility to each inbound purchase order and can dynamically allocate it to an outbound trailer when it arrives. At another extreme, some pure cross-dock locations are set up as staging areas and are not meant to carry inventory. These might be used to receive a full load from a DC into a metro area and break it up at the cross dock into local delivery loads.
In general, a very small percentage of product is being cross docked today, even though many warehouse managers—up to two-thirds—report that they opportunistically cross dock to some extent. Distribution centers do not want to tie up trailers, and especially tie up drivers, waiting for a cross-dock opportunity. Many companies turn to their 3PLs to manage the cross-docking operations. Others use a mixing center. A sophisticated warehouse management system can help, but the most advanced technology is useless without a lot of front-end work.

To execute a feasible cross-docking operation, companies need to lay the foundation with:

1. **Reasonably predictable demand**—without knowing the demand, sizing and staffing the operation are difficult.
2. **Appropriate products**—ideally the product involved would have a single, efficient method of handling.
3. **Reliable, efficient suppliers**—suppliers must deliver complete orders, on time, within narrow time windows. To do this, the customer must give their suppliers a stable order pattern and ideally high volume, single SKU loads.
4. **Expert service providers**—fast, reliable, consistent service is a must.
5. **Advanced systems**—cross docking is facilitated by sophisticated systems, including automated shipment notices, warehouse and yard management systems, a cross-dock management system, and track and trace capabilities.
6. **Facility design and layout**—inbound and outbound doors and facilities should be designed to maximize efficiency.
7. **Visibility**—easy access to current day inbounds and outbound allows a DC to opportunistically match them when possible.

This daunting list requires a multi-year journey to realize the full benefits of cross docking. That said, companies can and should get started by opportunistically cross docking without having all elements perfectly in place. As firms look to make the next big advance in DC productivity, cross docking merits a very close look.
Metrics and Planning
Developing a DC Management Strategic Plan

The distribution center strategic plan needs to be consistent with the overarching supply chain strategy. Unfortunately, our research shows that only 16 percent of companies have a documented, multi-year strategy for their supply chain. Paul Dittmann’s book, Supply Chain Transformation: Building and Executing an Integrated Supply Chain Strategy, (McGraw Hill, 2013) sets out a nine-step process for creating such a plan. Those nine steps, which have been slightly modified for DC management, are listed in order below:

1. Start with your customers; understand their needs
2. Assess your internal warehouse capabilities versus best in class
3. Evaluate the DC management game changers (i.e. the topics in this white paper)
4. Analyze your competition’s warehousing capabilities
5. Survey DC management technology
6. Manage risk by taking the time to identify, prioritize, and mitigate the high priority risks facing your warehousing operations
7. Determine new DC management capabilities, and develop a multi-year project plan to implement them
8. Evaluate the organization, people, and metrics
9. Develop the business case and generate buy-in

Metrics

Step eight in the strategic planning process includes choosing the best metrics that will motivate a successful warehousing operation. In our surveys, supply chain professionals from a broad range of companies used a scale of one to ten, with ten the most important and one the least important, to rank the following supply chain issues:

<table>
<thead>
<tr>
<th>Metric</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Implementing the right metrics and setting the right goals</td>
<td>8.15</td>
</tr>
<tr>
<td>Establishing collaborative relationships with suppliers and customers</td>
<td>7.91</td>
</tr>
<tr>
<td>Advances in supply chain visibility</td>
<td>7.80</td>
</tr>
<tr>
<td>Professional development, training, education</td>
<td>6.71</td>
</tr>
<tr>
<td>Helping with revenue generation</td>
<td>6.62</td>
</tr>
<tr>
<td>Managing the global supply chain</td>
<td>6.55</td>
</tr>
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The quest for the best metrics is clearly foremost in the minds of supply chain professionals.

**MAKE SURE METRICS HAVE A LOGICAL FRAMEWORK**

Key performance indicators need to be linked in a logical framework to the goals of the company. Otherwise, they are simply a laundry list of items with no apparent logic. For example, if the prime goal of the firm is to drive shareholder value, then a metrics framework should be established so that the organization clearly sees how every measure flows into and drives shareholder value.

In developing new metrics to support the strategy, a set of criteria must be in place to avoid poorly designed or seriously flawed metrics. For example, one firm we worked with defined a set of criteria to design the new metrics for its supply chain strategy. The metrics had to reasonably satisfy the following criteria in order to be part of the key performance indicator framework:

- Stable and accurate data with few large, random, or unexplainable swings
- Understandable to everyone, along with a line of sight, so that key personnel can see how their actions influence the metric
- Designed so that they cannot be easily manipulated or gamed
- Capable of drill-down analysis so that root causes of changes are apparent
- Clear cause and effect drivers
- Easily accessible for relevant parties, and available in clear reports, developed and published with clear explanations

These criteria served as a rigorous screen before a new metric was adopted and ensured a small number of very high impact key performance indicators.

**GOAL SETTING AND THE IMPORTANCE OF BENCHMARKING**

Selecting the right metrics and defining the associated responsibilities is important. Establishing goals is an entirely different matter. Too many companies only use internal comparisons, this year versus last year for instance, and feel good about achieving an internal goal. Leading companies benchmark best in class performance and then set goals accordingly.

**The Best Warehouse Metrics**

We asked a wide range of distribution center management professionals their opinion of the best metrics for warehouse management. The responses centered on five areas safety, customer service (on time delivery, order cycle time, order accuracy, and damage), cost and productivity, asset management, and people development/morale.
SAFETY

Safety, covered later as a separate theme, should be the number one objective of any operation, and warehouses are no exception. Safety is a mindset reinforced in many ways, many of which we discuss in the safety section below.

Safety is often measured as the number of incidents or recordables, lost time accidents, times since the last accident, or near misses. Near misses are a very valuable metric giving a leading indicator of recordables or lost time accidents. To capture near misses, a firm has to rely on the commitment of its management team and hourly associates to record a near miss in writing and submit it to the system. Safety metrics should be highly visible to the entire workforce.

One company included safety metrics on the balanced scorecard of every employee in the supply chain organization, including planning and inventory management, not just the logistics operations people. This heightened the awareness of the entire supply chain organization to safety issues.

CUSTOMER SERVICE

Some organizations group customer service as part of their quality metrics because failure to serve a customer’s needs is clearly a quality defect. Therefore, customer service key performance indicators are ideally expressed in defects per million. Ninety-nine percent good seems acceptable until one realizes it represents 10,000 failures per million. Customer service metrics tend to be focused on:

- Order accuracy and pick accuracy
- Damage
- Order fulfillment time vs. standard
- Incorrect paper work, including the invoice
- On time shipment, or on time delivery to a customer’s service window

The best practice is for customer service to be measured and reported by the customer.

COST

Cost metrics tend to be dominated by productivity measures, since labor generally represents most of the facility’s operating cost. It is important to break cost down into its main components: receiving, put away, picking, shipping, maintenance, and management. Typical key performance indicators that measure cost productivity are units or cases per man-hour, picks per man-hour,
Managing risk in the global supply chain.

### Metrics and Planning

Cost per pick, cost per carton, through-put rates, et cetera. One firm said that they measure cost per “blended unit,” where a blended unit represented one item picked. It could be a case, or it could be an “each.” Another firm said that they moved to a “cost as a percentage of sales.” They did that in order to make sure the logistics operation cared as much about sales and revenue generation as it did about cost. Another best practice is to use a weighted average cartons or units picked per hour, because all cartons/units were not created equal.

Time measures can also be quite powerful, such as time from order receipt to fulfillment and then time to shipment. Also important is time from inbound arrival to unload and time to put away.

One company found that productivity metrics alone drove an excessive investment in automation. Management remedied that by including the depreciation cost of the automation in its total cost analysis.

Capturing and tracking cost metrics beyond direct labor is also important. This includes items like indirect labor, contractors, overtime, and health care. Some companies compare distribution centers in an ordered ranking by key metric. While this is somewhat unfair since nothing is ever apples-to-apples, it is still motivational. No one wants to be at the bottom of any such list, and anyone at the top wants to stay there.

Since distribution centers are responsible for loading trailers, they assume the burden of making sure that the equipment is as fully utilized as possible. One retailer who rigorously manages cube utilization gets a 3,000 cube in the average fifty-three-foot trailer (a trailer has 3,800 cubic feet of space). This very positively impacts transportation cost.

### Asset Management

Assets consist of physical capital and working capital. Physical capital includes warehouse space as well as the equipment, automation, and systems used to operate the warehouse. Working capital consists mainly of inventory plus receivables minus payables. Maintaining accurate inventory is a critical responsibility of warehouse operations. Leading companies not only measure if the right inventory is in the building, but also if it is in the correct place in the building. On time delivery triggers the invoicing/payment process, and therefore initiates the receivables process, receivables being a critical component of working capital. Procurement, a supply chain function, manages payment terms to suppliers, and therefore strongly influences accounts payable. Therefore, supply chain has a major impact on all three buckets of working capital: inventory, receivables, and payables.
The concept of a balanced scorecard means that qualitative metrics are also critically important. These often come into play in the people development and management area, which we cover in the People section in this white paper. Some examples of important metrics to consider are:

- Evaluations completed
- Professional development plans in place
- Education and training completed
- Turnover and reasons for it (One firm estimated a $9,000 cost for each hourly associate replaced, not counting the learning curve effects. Turnover also is a good surrogate measure of morale.)
- High potential employee development plans completed
A modern warehouse management system is critical to the efficient management of any medium to large sized warehouse. One large retailer even installed a warehouse management system in their retail store’s backrooms, especially after the supply chain organization assumed responsibility for moving product to the retail shelf. While this may sound like gross oversimplification, essentially warehouse management systems improve productivity by minimizing movement in the warehouse. The idea is to reduce operator and equipment movement as much as possible to minimize the cost and number of people required to run the warehouse. This arguably leads to an even more important result, namely a speed up of customer order fulfillment times.

**Warehouse Management System Functionality**

To choose the correct WMS, the needed functionality must be identified first. Some of the most common capabilities of warehouse management systems and common bolt-ons are:

**GOODS RECEIPTS.** The best practice is to match the advanced shipment notification with the bar codes, often using a handheld device. The system then indicates the best location to store the goods and should also trigger the vendor payment cycle. In FDA-compliant facilities, during the goods receipt
process there is an additional step of quality control. Inbound loads are inspected to ensure that they are not damaged, have the proper labeling, are released from the customer for storage, and meet expiration date business rules.

PUT AWAY. The system optimally routes any lift truck vehicles, as well as operators on foot to minimize distance traveled. The system helps consolidate locations during the put-away process and optimizes space utilization by ensuring SKUs are placed in locations that need to be topped off instead of choosing a new empty location. It optimally places the SKU in a location that supports velocity movement and considers any promotional or substitution business rules in deciding where to place SKUs in the DC.

profilING OR SLOTting. The warehouse management system can analyze SKU movement velocity and recommend where to place SKUs in a warehouse to minimize picking requirements and congestion.

PICKING. The warehouse management system can ensure that movement is minimized in picking an order. It interfaces with, and drives, any picking technologies. The WMS allows for multiple orders to be picked simultaneously to minimize operator travel distance, and this practice is referred to as “task interleaving.” Task interleaving can combine put-away tasks with picking tasks. For example, a driver has a put away of SKU A on Aisle X and there is an order for SKU B that is also on Aisle X. Task interleaving would immediately give the picking task to the driver as soon as he confirmed the put away, allowing him to stay in the same area.

SHIPPING. A final check matching data in the warehouse management system should be made at the dock to ensure 100 percent accuracy in the shipment. Some warehouse management systems, or associated bolt-ons, have a capability to optimize trailer loading or facilitate loading, particularly in a multistop environment.

REAL TIME VISIBILITY INTO INVENTORY AND ORDERS. The warehouse management system interfaces with the enterprise resource planning transactional system to provide real time visibility of inventory and orders.

lABOR MAnAGEMenT. Labor management systems are often embedded in, or bolted onto, the WMS. Labor management software reports on the performance of individual associates against discrete standards or goal times for tasks in the distribution center. A labor management system can analyze historical data for an accurate estimate of warehouse throughput. Then it can schedule the right balance of overtime, as well as regular and temporary labor, required for shifting demand patterns.

YArD AnD DoCK MAnAGEMenT. The warehouse management system and yard management system direct inbound trailers to a particular dock door to minimize receiving and put-away time. Outbound trailers are called to docks as they are needed, based on pre-established priorities. Trailers are checked
into and out of the yard, and sealing and unsealing of equipment is monitored. All yard stock should be visible. Some yard management systems utilize active radio frequency ID tags to quickly identify what is inside a truck and where the trailer or container is located. The WMS/yard management system can allow only authorized personnel to use gas pumps, and then record the amount of fuel pumped. It can interface with electronic seals and send an alert if a seal has been broken.

**CROSS DOCKING.** With a cross-docking capability, inbound loads are matched with outbound deliveries and cross-dock opportunities are dynamically and opportunistically detected.

**INVENTORY CYCLE COUNTING.** Routine cycle counting is managed to achieve excellence in inventory accuracy. Warehouse personnel are directed to count SKUs on a rotating basis throughout the year. Sophisticated cycle counting systems have different rules by SKU family (i.e. fast movers are counted on a more frequent basis).

**INTEGRATED WITH ENTERPRISE RESOURCE PLANNING SYSTEM.** Integration provides a seamless transfer of order data to the warehouse management system, and a transmission of shipment and inventory data to the enterprise resource planning system.

**REVERSE LOGISTICS.** The warehouse management system can also manage returns. If left to ad hoc manual processes, returns can create major inefficiencies in warehouse operations.

**SMALL PARCEL MANAGEMENT.** This is typically a bolt-on to the WMS and can choose the best method for shipping small parcels, Fed Ex, UPS, and US Postal Service.

Ninety-five percent of all warehouse management system users employ their WMS for the first four functions above: receiving, put away, picking, and shipping. The other functionalities are less used. For example, less than 10 percent use their WMS for cross-docking assistance. Twenty-four percent use task interleaving. Only 35 percent use a mature yard management system dock management capability. Fifty percent use profiling, and 70 percent use their WMS to enable cycle counting and inventory accuracy.

A major challenge that some firms have is multiple warehouse management systems. This is especially true of companies that have grown by acquisition. Standardizing warehouse management systems is expensive and time consuming, and the ROI must be clear to undertake such a major initiative.

Many distribution centers cannot operate at all if their WMS goes down; therefore there must be a culture of 100 percent uptime for it. Given the scope of this advancing technology, the WMS should probably go through an upgrade every five years.
Automation

Many Lean advocates have an appropriate mantra as we noted above: eliminate before you automate. Otherwise waste becomes hardwired into the operation. That said, technology continues to advance, and automation systems are becoming increasingly more viable. A growing number of automated material handling systems have sensors and intelligence that optimize performance. Even forklifts are getting more sophisticated. Today’s smart forklift includes diagnostics that provide alerts for required service, collision detection, fork speed optimization, speed controls for busy sections of the DC, and more.

Many processes may need to be controlled and optimized in a distribution center, from modern conveyor systems to automated guided vehicles and automated storage and retrieval systems. Maybe in the not-so-distant future warehouse operators will control automation using hand signals, reminiscent of Wii video games, or use Google glasses as a guide to their movement in the warehouse. A worker at a dock might use a simple hand signal captured by digital image to trigger a conveyor. At a more basic level, a robust Wi-Fi capability will be important to support wireless devices like rugged tablets.

Because of the increase in automation, warehouse execution software is also emerging as a critical systems tool in the large, modern distribution centers. Warehouse execution software systems provide the foundation to run automation systems, but they need to be interfaced with the warehouse management system. The warehouse execution software must know the real time statuses of all the automated equipment in the DC such as conveyors, carousels, and picking systems, and interface them with the WMS.

In summary, thanks to recent technological innovations, the benefits of warehouse automation are becoming more accessible. Companies are increasingly automating processes such as put away, picking, sorting, and palletizing. If implemented properly, automation can reduce labor and increase productivity. Automation can also reduce cycle time and provide the capacity for strategic growth. The large up-front costs require scale, however, and automation systems can be costly to change once installed. Therefore, the ROI needs to be done realistically, and the implementation needs to be highly disciplined. That said, it is a good time to reconsider the preconceived notions about automation, as technology continues to advance.

Choosing a Warehouse Management System

The annual sales volume of warehouse management systems exceeds one billion dollars, drawing many players in the space. Warehouse management systems can be obtained from many software companies, including Manhattan, SAP, JDA/RedPrairie, High Jump, Oracle, and countless others. It is increasingly common for companies to use cloud-based systems, Software as a Service (SaaS), that have been around for about a decade. One survey said that 64 percent of
DCs have a WMS, but only 8 percent are cloud based. In a recent survey by SCM World (the supply chain talent development partner for many leading companies), 53 percent of supply chain practitioners surveyed across industry think of cloud computing as “interesting, but having unclear usefulness.” This is a more tepid response than what is heard from IT professionals and tech companies. These professionals tout the advantages of a cloud-based system, such as:

- Lower implementation cost
- No hardware to buy
- Faster time to payback
- Lower up-front cost by avoid a large licensing fee
- Portability of facility moves
- Automatic upgrades

Potential customers of a cloud-based system must determine the costs over the total life cycle, and these are not necessarily lower. Also, response time should be determined with a cloud-based system to avoid unproductive waiting by operators. Cloud-based systems can be extremely difficult to customize. Warehouse Management Systems have multiple touch points where the application must interface with other systems in the DC and outside the DC such as the transportation management system and the enterprise resource planning system. In addition, substantial unique configuration of the software could be required to interface with sophisticated material handling equipment. Cloud based systems may make more sense for small companies who don’t have the resources to deploy a WMS, or for a larger company that wants one standardized system for multiple sites.

To choose the appropriate warehouse management system, leading companies first develop a list of requirements. Then they invite prominent WMS vendors to demonstrate how their software meets those requirements. “See it before you believe it” is a good philosophy; software vendors have been known to exaggerate. A number of elements germane to the selection are:

- Vetted references
- Ability to integrate easily with the existing enterprise resource planning or legacy systems
- Licensing cost, and ongoing support cost
- Estimated ROI
- Scalability and flexibility to accommodate future requirements
- User friendliness
- Financial viability of the supplier
- Quality of after hours support
- Cost-benefit analysis
- Stable software, unless there is tolerance in the firm for a beta version
- Buy-in of the line organization
A scoring system, such as a rubric based on the above criteria, should be used for software selection. To enhance buy-in, the scoring team should be large and cross functional. Each element in the evaluation criteria should be listed and weighted for its relative importance. For each major capability required, the scoring could be something like:

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<tr>
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<td>Partially meets needs</td>
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<tr>
<td>3</td>
<td>Meets needs but open questions remain</td>
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<tr>
<td>4</td>
<td>Meets Needs</td>
</tr>
<tr>
<td>5</td>
<td>Meets and exceeds needs</td>
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Once the weighted totals are tabulated and a good dose of judgment applied, the decision should be clearer.

**Change Management**

Any new technology implementation always has major change management issues with which to contend. In several surveys, we have found that supply chain professionals rank implementation difficulty as follows:

- **Culture** 50%
- **Process** 35%
- **Tools** 15%

In other words, half of the implementation challenge is culture based. Therefore, the lion’s share of the challenges comes from cultural issues, not technical issues. We believe four key principles of change management should be addressed.

1. Sustaining change is harder than the initial implementation. Have a plan to sustain the change.
2. Getting buy-in is time consuming. Put communication tasks in your project plan and plan the time to do it right.
3. Manage expectations carefully.
4. Focus communication on the key individuals.

These four considerations should form the foundation for a documented change management plan.
Layout and Space Optimization

Productivity declines exponentially if distribution centers become too crowded and the docks, staging areas, and aisles become congested with product. In addition, over crowding often drives a company into extremely expensive overflow warehousing. Therefore, it behooves any firm to make sure that they have given warehouse space optimization the priority it deserves.

One durable goods company told us that they had over 8 million square feet of warehousing space but were experiencing severe space shortages. They launched a number of initiatives to consolidate and averaged saving just over 10 percent of the space in each warehouse. That amounted to 800,000 square feet of additional warehouse space, which they avoided having to pay for at $40.00 per square foot or $32 million. What were the initiatives that this company used to create to optimize so much warehouse space? Below are some ideas that worked for them and others.

**Eliminate Honeycombing.** Honeycombing is a symptom of too many slow-moving SKUs, which consume their space in a sporadic and partial manner, creating an uneven, “honeycomb” look to the stacks in the warehouse. Leading companies group or consolidate slow-moving or obsolete SKUs in remote areas of the warehouse. They find that combining slow movers in the same area takes a modest amount of additional labor but saves major amounts of space.
Managing Risk in the Global Supply Chain

If DCs become too crowded and docks, staging areas, and aisles become congested with product, productivity declines exponentially.

Racking and Mezzanines. If products are not stackable, then racks and mezzanines can be used to effectively fill the cube of a warehouse.

- Racks need to be safe. Single deep racks not anchored to a wall or columns are inherently unstable. Lag bolts to the floor are helpful but not adequate. Back-to-back rack installation is much more stable and thus safer. The prime risk to racking is accidental collision with forklifts.
- Warehouse racking should contain sufficient capacity to handle every SKU that cannot be stacked.
- DCs should evaluate the feasibility of mezzanine space over every area that does not fill the warehouse cube.

Stacking Height and Product Stackability

- Stacking heights should be challenged if the warehouse cube is not full. One DC had one-ton bags of a chemical product stacked in racks three high. In addition, they had a major amount of overflow product stored in trailers in their yard. This generated a huge cost for trailer rental. Later, they realized that three-high stacking was simply a traditional paradigm dating back to the warehouse’s inception rather than safety protocol. They moved to four-high stacking, which increased the size of the warehouse by 33 percent, and eliminated millions in overflow storage cost.
- Sometimes product packaging inhibits the ability to stack product in a warehouse. Product design engineers, in their zeal to reduce cost, can make it impossible to stack product in a warehouse just to save a few cents on cardboard. This wastes huge amounts of DC cube. Packaging needs to be even more robust in some environments like warm climates with high humidity.
- Stacking may be inhibited by local statutes like fire codes.
- As noted above, strategic use of mezzanines can better utilize the warehouse cube, especially when placed over nondistribution functions.
- Warehouse space above 30 feet is likely inefficient to retrieve with lift trucks and may best be served with an automated retrieval system.

Eliminate Nondistribution Functions. Nondistribution functions are often carried out in a DC, such as:

- Customization of units with unique branding and labeling, packaging, final assembly, and kitting;
- Postponement activities;
- Handling of returns, refurbishment of damage, repackaging, and storage of components to support these functions;
- Using maintenance areas, and space for lift truck parking and battery charging, as well as maintenance supplies;
- Offices.

Layout and Space Optimization
Step one is to document the space and warehouse cube allocated to activities such as these. Then ask if there is a better way that wastes less of the DC cube. For example, these activities might be placed in or under mezzanine areas to better consume the DC cube.

**WAREHOUSE LAYOUT: DOCKS AND AISLES**

- How wide should aisles be? If fourteen-foot aisles are traditionally used, perhaps twelve-foot aisles should be considered. Aisles take up a major amount of DC cube. Aisles should be as wide as necessary, but no wider.
- Many software tools are available, from sophisticated computer aided design systems (i.e. SIMCAD) to tools anyone can download from the Internet. Some can produce a three-dimensional, digital layout of the warehouse, and then model and optimize space based on a set of constraints. Various layouts can be simulated and animated. Three-dimensional simulations can be built to allow managers to identify problems before they are hardwired in place.

**RECEIVING AND SHIPPING.** Receiving and shipping functions, although critical to the efficiency of the overall warehouse operation, often have either too much or too little space allocated to them. Some up-front analysis is in order. To properly design the receiving and shipping areas, one must know:

- Type of material to be shipped and received,
- Frequency of activity now and in the future,
- Nature and numbers of vehicles,
- Types and numbers of docks,
- Staging area required, and
- The Pareto distribution. (i.e. 80 percent of the activity will be generated by 20 percent of the items)

With such data, leading companies can use a tool to simulate dock activity to make sure that any bottlenecks are identified and the proper amount of space allocated.
Several supply chain professionals have told us, and we agree, “If you haven’t completed a network optimization study recently, you are probably leaving a major savings opportunity on the table.”

A network optimization answers questions such as:

- How many DCs should you have?
- Where should they be located?
- Which customers, stores, or locations should each serve?

Many retailers routinely tweak the stores served by each DC with multimillion-dollar savings annually. Both retailers and manufacturers can evaluate and change the structure of their DC network to produce major savings. Some firms do a network refresh on a periodic schedule, like every two to five years.

Some very powerful software tools are available to assist in this endeavor. Most are optimizers, which can minimize cost while satisfying a series of constraints, such as those from customer service. Some also use a simulation capability to accommodate more extensive and realistic data sets, as well as probabilities. Optimization studies can get very large for a complex network. Some companies attempt to consider a wide range of variables, such as the location of suppliers, customers, and factories. One company’s model included a mind-boggling: 12,089 variables; 58,552 constraints; and 2.9 trillion input parameters. Even with modern computing power, the data set on optimization studies must often be simplified. Fortunately Moore’s Law, the idea that computing power doubles every two years at no additional cost, is gradually resolving that problem.

Llamasoft is a good example of a leading provider of network optimization software. Most companies use outside expert assistance, such as consultants or a 3PL, when they conduct studies like this. A few leading companies have in-house teams often staffed with people who have industrial engineering backgrounds. One company has a supply chain engineering department, another has a global analytics group, and yet another has an in-house strategy group to perform such studies. Many companies do a network refresh study on a routine basis, approximately every two to five years. In between, analytical people can also do quick and dirty studies effectively if the scope is limited.

Many organizations are reevaluating their networks in light of the Internet boom. They study whether website orders should be served out of store, regular DCs, or specialized DCs.
A network optimization study is as much art as science. A great deal of management judgment must be applied to successfully complete an implementable plan. And of course, once a general location for a DC is selected, many other factors come into play to select a specific site such as:

- Proximity to manufacturing plants
- Distance to market/customers
- Real estate/leasing conditions
- Local cost of living
- Available workforce, skills and flexibility
- Local transportation, both inbound and outbound

Network optimization studies are traditionally difficult and quite resource intensive. They are challenging for many reasons:

- Organizational boundaries are crossed
- Data requirements are massive
- Often the data must be corrected (Most companies have extensive errors in their data.)
- Projects are large and require dedicated resources
- Uncertainty exists in many variables
- Implementation requires extensive change management

A good rule of thumb is that assembling and cleansing the data will take 70 percent of the project time. As one experienced executive noted, “It will take at least twice as long as the most pessimistic person thinks.” Therefore, management of scope for such projects becomes critical.

There are often unintended positive benefits to a network optimization study. For example, to feed the model, one analyst needed data on loadability for a certain small boat manufacturer. (How many units were loaded in each truckload?) When he learned two boats were loaded in each truck, he naively asked, “Why so few?” That simple question motivated people in the firm to challenge the paradigm and eventually increase that number to six units per truck. At another company, a large number of errors had been discovered in the data and many numbers had to be corrected for the model. These data were used in other applications for important company decisions. By cleaning the data, other applications also performed much more accurately.

*If you haven’t completed a network optimization study recently, you are probably leaving a major savings opportunity on the table.*
Safety and Security

When asked for their highest priority, warehouse professionals more often than not say safety is number one. Safe DC operations require a combination of mindset/culture, metrics, and processes.

**Safety Mindset/Culture**

Everyone in the facility every day needs to think safety. That starts at the top when senior executives state openly and often, “safety is our number one priority.” Norfolk Southern Railroad has a rule: Every meeting in this company will begin with a safety briefing. Another firm calls this a “safety share” at the beginning of every meeting. Although most would consider that overly tedious, it sends a message to every employee, every day. Other companies feel they can make the point with monthly focused safety meetings. Some firms put safety in their corporate mission statement. Some state it clearly in their corporate values. Some have an official safety strategy which they update every year.

Honeywell requires that employees and visitors watch a safety video, and employees go through regular safety training. Once completed, the visitor receives a card that must be shown each time entering the facility. A safety briefing is appropriate for all visitors to DC facilities, including basic information such as how to exit the building in an emergency. One firm briefed visitors on the way to avoid any toxic fumes, telling them, “When you exit, look at which way the flags are blowing and proceed up wind.”
Safe operations relentlessly require people to wear the proper clothing, including safety glasses, hearing protection, orange vests, and when appropriate gloves, sleeves, and steel-toed shoes. Visitors on a simple tour are no exception to these dress code rules.

As mentioned earlier, Lean operations often add a sixth “S” for safety to their 5S process, further enhancing the safety mindset. One corporation has a safety wall in each DC. These are large, twenty-five-foot long displays showing safety stats and celebrating milestones. Another company has large safety celebrations when they reach a milestone with no lost time injuries. They said they spend $25,000 per DC on a cook out and give-away merchandise. One firm encourages associates to put up pictures of their loved ones, employing a “Do it for them” campaign. All of these actions contribute to a culture of safety.

Actions speak louder than words. It’s never acceptable to sacrifice safety when some other objective becomes paramount. Labor productivity, output and/or quality are all critical to survival, but employees can never see safety take a backseat to any of them.

Temporary employees represent more of a challenge. One company told us that temporary employees experienced reported safety problems 40 percent higher than regular employees. When asked why, the answer seems to be a combination of too little vetting (drug screening, previous work history) and too little training.

Safety needs to be everyone’s responsibility. One company selects a safety advocate for each facility. The job can be done on a rotation basis, and the individual should be accountable to oversee training, metrics, and safe processes. Another firm has a safety committee in each DC led by an hourly associate. They believe safety is all about total employee involvement and ownership. This firm required all 10,000 of its employees to take five modules of safety training. Leading companies understand that safety can’t be punitive or else the associates will not participate. The hourly associates must own safety and aggressively report unsafe acts.

When considering safety, the subject of hazardous materials cannot be ignored. A material safety data sheet provides workers and emergency personnel with procedures to safely work with that substance. Material safety data sheets should be kept up to date with information such as physical data (melting point, boiling point, flash point), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill-handling procedures.

**Safety Metrics**

Safe operations have visible metrics along with serious accountability for them. Common safety metrics include:

- OSHA recordables and lost time events
- Corrective action completed to address safety problems
Leading corporations track these metrics over time and make them highly visible throughout the operation.

Tracking the most common and the most severe injuries to determine their causes is important. For example, the most common injuries may be musculoskeletal injuries caused by lifting, pushing/pulling, slips, trips, and falls. The most serious injuries often occur when someone is caught between or hit by equipment. A fatality is horrific and often results from what is initially perceived as a freak event. One company had a fatality when someone simply jumped off the end of a truck dock. At the root of any such horrible occurrence is the opportunity to make fundamental safety changes.

**Safety Processes**

Safe operations have safe processes. Safety audits should be performed on a periodic basis. Organizations should be relentless about meeting and exceeding all OSHA standards. A few things to look out for are as follows:

- Unsafe use of forklifts (People need to be separated from lift trucks by guard rails whenever possible.)
- Electrical dangers
- Improper ventilation or handling of hazardous materials
- Improper stacking
- Failure to use personal protection equipment
- Failure to have strict lockout/tag out procedures for equipment being serviced.
- Inadequate emergency systems for fire or injury like chemical burns
- Improper storage and handling of hazardous materials
- Improper procedures for repetitive motion or lifting
- Unprotected pinch points around conveyors for example
- Bad general housekeeping—cluttered aisles and docks
- Failure to block or protect dock doors
- No cages over ceiling lights to prevent glass from dropping
- Failure to adequately prevent explosion risks like smoking around charging stations
- Poor lighting
- Failure to protect pickers in stacks with enclosed cages or a failure to continually wear a harness on high-rise vehicles

When asked for their highest priority, warehouse professionals more often than not say safety is number one. Safe DC operations get that way from a combination of mindset, metrics, culture, and processes.
Security

Security to avoid theft and pilfering is more important for some products than others. Truckload value does not have to be astronomical to merit security measures. Dishonest employees can defeat the most elaborate security system for high value items or high theft items like electronics, liquor, or drugs. That’s why front-end screening must be very aggressive in such facilities, even including polygraph or voice-stress analysis. High theft items must be placed in their own secure areas.

Only certain employees should be able to enter secure areas, and/or break seals. The temptation grows once cartons are opened. Modern, hard to defeat electronic alarm systems are a must. High fences, even guard dogs, around a warehouse perimeter help. There should be a rigorous sign-in/sign-out procedure and a badging program. High-resolution cameras, metal detectors (for everyone, even visitors, and the boss), and turn styles can be essential security devices where appropriate. There should only be one way in and out of a DC, barring an emergency situation, and that entrance/exit should have detectors. Trailer yards can also be a weak point. Tractors and trailers have been stolen from secure fenced-in areas.

Companies should hire a good security expert to oversee security systems. One company has loss prevention personnel on site around the clock to man cameras, administer entries and exists from the facility, and inspect outbound trailers. Sources may be people with backgrounds in government agencies like the FBI, Secret Service, or military police, or people who have worked for security firms like ADT.

On a global basis, the Customs-Trade Partnership Against Terrorism (C-TPAT) is a voluntary supply chain security program led by U.S. Customs and Border Protection. It focuses on improving the security of private companies’ supply chains with respect to terrorism. The program was launched in November 2001 with seven initial participants, all large US companies. Today, the program has over 10,000 members. The participants in the program account for well over half of all merchandise imported into the United States. Companies who achieve C-TPAT certification must have a documented process for determining and alleviating risks throughout their international supply chain. These companies are considered low risk, so they receive expedited cargo processing and fewer customs examinations.
People

Having the right people in the right jobs is key. Leading companies excel in five areas when they manage talent, and their DC operations’ talent management should be no exception. The five steps in a good talent management process are: assess needs, identify job candidates, hire, train and develop, and retain.

These principles are detailed in the University of Tennessee’s white paper “Talent Management for the Supply Chain” (coming Spring 2015).

As was mentioned in the section on Lean warehousing, it is essential that all associates in a warehouse operation be engaged and involved in continuous improvement. Some companies have success with self-directed workforces. The supervisors become problem-solvers, and the associates take on routine supervisory duties including hiring, work scheduling, and job rotation. Although more challenging, this has also been successfully implemented in unionized environments.

Leading companies invest in training for new employees as well as ongoing training. Leaders also find a way to retain good employees and minimize turnover; they pay a fair wage for the area, show appreciation, and foster an atmosphere of ownership by involving employees in DC improvements.

Personnel planning for DC operations is a large and complex task, and it is beyond the scope of this white paper. Topics such as labor standards and measurement, labor incentive systems, union issues, work hours and shift
rotation are best covered in other sources, such as Gwynne Richard’s book *Warehouse Management, A Complete Guide to Improving Efficiency and Minimizing Cost in the Modern Warehouse*.

**Third Party Logistics Operators**

An increasing number of companies use third party logistics to manage their DC operations; this includes hiring and managing the hourly associates. There is a continuing trend toward more firms outsourcing their DC operations to 3PLs. Third party logistics firms can do many additional things such as:

- Reduce future cost by leveraging the 3PLs expertise and technology
- Improve customer satisfaction
- Provide a contingency plan for union issues
- Reduce risk
- Reduce current cost
- Provide global expertise, including documentation, customs, and duty optimization

Great people, management and hourly associate personnel, are essential to accomplishing those goals. The survival of a 3PL depends on the caliber of the employees. Many 3PLs partner with an employment company. These partner agencies thoroughly vet personnel, as well as provide some training.

**Hourly Associates**

Often, new hourly associates are temporary workers for ninety days before becoming full time employees. Sometimes the firm or 3PL pays less than competitive wages during this initial period. This practice is counterproductive in that it often leads to more turnover, which can be over 100 percent for temporary workers, and fewer ideas for improvement brought forward by the associates. Of course higher wages don’t automatically lead to better results. They must be coupled with the right culture and processes.

Firms that develop and retain great management talent have a clear advantage over those who don’t have a formal plan. One professional observed that many professionals ask, “What if we train and develop our management team and hourly associates and they leave?” His retort, which we believe is the correct question, “What if we don’t develop them and they stay?”

Many DCs need an extremely flexible workforce that is comfortable with highly variable working hours. The work mirrors the shipping pattern, and often shipping/demand patterns are highly variable.

*It goes without saying that having the right people in the right jobs is the key to everything. Leading companies are excellent at managing talent, and their DC operations should be no exception.*
Kaizen

Hourly associates always provide the best source for kaizen, or continuous improvement, as discussed in the section on Lean. One company instituted a structured suggestion program and received over 500 employee suggestions in nine months. The suggestions lead to savings of hundreds of thousands of dollars and countless safety improvements. Supervisors need to focus on being problem-solvers rather than bosses. Sadly, not all supervisors can get with this program. Another company noted that if you don’t involve people, they will focus their substantial brainpower on other things, and in particular they will work very hard to not work hard.

Management Personnel

Each professional in the organization should have a personalized development plan that is tracked. Some companies invest heavily in their in-house development. For example, Kenco has a leadership development program with quarterly one-week training sessions over an entire year. The great majority of the program’s graduates have stayed with the company and have been promoted. Kenco also annually sends two employees with high potential to the University of Tennessee Global Supply Chain executive MBA program. Modern executive MBAs like these can cost upwards of $100,000, but they have been proven to generate ample ROI for the sponsoring company. Progressive corporations view people as an asset, not an expense. Not only are people an asset, but also they can and should be an appreciating asset. Even in tight times, a training budget needs to be liberal and protected.
Sustainability

The green revolution is upon us. More often than not, the supply chain is at the forefront of these organizational changes. The extended supply chain generates much of the carbon emissions for most firms, so it makes sense for the supply chain team to lead the charge on corporate sustainability. Clearly warehouse operations are key to an overall supply chain sustainability effort. In one large company, the senior vice president of supply chain reports directly to the corporate executive vice president of sustainability.

Distribution Centers can do many things to be green, and fortunately many of them have a financial payback. Most supply chain professionals pursue green initiatives to cut costs, although public relations and brand image can also play a role. Some common green initiatives are:

- Cardboard recycling, which can turn into a lucrative business for some companies
- Plastics recycling and minimization of the use of shrink-wrap
- Moving from propane to electrical lift trucks (The next step may be fuel cells that run on hydrogen and emit water vapor. Today the ROI on the required cost and infrastructure is problematic, but that should change over time. Many companies are running pilot programs with fuel cells.)
- Working with vendors to reduce packaging materials (Some DCs must have large trash-cutting operations to remove excess packaging. A large industry consortium has been formed with the goal of eliminating inner packaging material, working with the outstanding packaging engineering program at Michigan State University. Twenty-five companies recently participated in a conference on that topic.)
- Returnable and especially collapsible containers
- Reuse of wood pallets, even making mulch with worn out pallets
- Caulking and weather stripping around windows and doors, seals around dock doors, and appropriate insulation
- Automatic adjustments to the HVAC system when the building is not in operation
- Natural lighting such as skylights or solar panels. One DC in California said that they have solar panels covering the entire 700,000-square-foot roof. Several firms said that solar panels have a very low ROI, but “seem like the right thing to do”
- Motion detectors for lighting in low traffic areas and photo sensors for outdoor lighting
- Less lighting where it is not needed
Efficient lighting systems—lighting is the largest energy cost in most DCs (LED fixtures with intelligent integrated controls, sensors, and reporting can save an estimated 50 percent of lighting costs. There can also be both local and federal tax incentives for projects like this. The payback on the investment is generally about eighteen to twenty-four months. The ROI depends on a range of factors such as number of shifts, ceiling height, the local cost of electricity, incentives, and activity in the various zones of the warehouse. Intelligent motion sensors also save lighting cost. After no motion for a specified time the light can dim and then later shut off completely.)

Often lighting is the easiest energy issue to address, but it is important to track all energy—not just electricity. Electrical usage, natural gas, propane, water, and sewer, should all be tracked and monitored, with usage goals set for each.

**Conclusion**

The incredible scope of DC management clearly requires the best and brightest of management personnel. This job demands innovation, technical acumen and human resource skills. DC managers must manage upward to respond to very tough management goals and customer expectations. They must also manage downward to engage all employees in a journey of continuous improvement. The relentless challenge for companies is to find and retain talented people who can manage the incredibly difficult, ever-changing DC operations of the future.

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**About the Global Supply Chain Institute**  [http://globalsupplychaininstitute.utk.edu/](http://globalsupplychaininstitute.utk.edu/)

The Global Supply Chain Institute at the University of Tennessee has one of the premier supply chain programs in the country. UT offers undergraduate, MBA, and doctoral student education within the field, and its thirty supply chain faculty members are ranked No. 1 for academic, supply chain research productivity.

**About Kenco**  [www.kencogroup.com](http://www.kencogroup.com)

Kenco is the largest woman-owned, third-party logistics company in the United States. The company provides fully integrated logistics solutions that include warehousing, distribution, asset and non-asset based transportation, complex information technology systems, engineering, real estate, and material handling equipment—all engineered for operational excellence.
## Distribution Center Evaluation Tool

Note: this tool applies only to larger DC operations

### Please rate each item on a 1-10 scale, where 10 is world-class

<table>
<thead>
<tr>
<th><strong>Receiving</strong></th>
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<tbody>
<tr>
<td>1. Do you receive ASNs on most of your inbound receipts?</td>
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<tr>
<td>2. Do your suppliers deliver high quality shipments on time, with accurate counts?</td>
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<tr>
<td>3. Do you have a robust process to manage returns?</td>
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<tr>
<td>4. Do you quickly put product away and in a place best for picking?</td>
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<tr>
<th><strong>Warehouse Management Systems</strong></th>
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<tbody>
<tr>
<td>16. Do you have a modern WMS in place?</td>
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<tr>
<td>17. Do you effectively use an appropriate level of the WMS's functionality?</td>
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<tr>
<th><strong>Layout and Space Optimization</strong></th>
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<tbody>
<tr>
<td>18. Do you effectively utilize the full cube in your DC locations?</td>
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<tr>
<th><strong>Network Optimization</strong></th>
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<tbody>
<tr>
<td>19. Do you do a network optimization study at least every five years to refresh your supply chain network?</td>
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<tr>
<th><strong>Safety and Security</strong></th>
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<tbody>
<tr>
<td>20. Do you have an intense safety mindset and culture?</td>
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<tr>
<td>21. Do you have visible, impactful safety metrics?</td>
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<tr>
<td>22. Do you have safe processes?</td>
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<tr>
<td>23. Is your DC secure from pilferage?</td>
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<tr>
<th><strong>Lean Warehousing</strong></th>
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<tbody>
<tr>
<td>9. How advanced are Lean philosophies and processes in your DCs?</td>
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<tr>
<td>10. Do you heavily involve the hourly associates in your improvements efforts?</td>
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<tr>
<td>11. Do you have a robust Six Sigma process in place?</td>
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<tr>
<th><strong>Cross Docking</strong></th>
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<tbody>
<tr>
<td>12. Do you have a mature cross-docking process, appropriate for your operation?</td>
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<tr>
<th><strong>Metrics and Planning</strong></th>
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<tbody>
<tr>
<td>13. Do you have a documented, multi-year strategic plan for your DC operations?</td>
</tr>
<tr>
<td>14. Do your metrics have a logical framework, along with appropriate goals?</td>
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<tr>
<td>15. Do you have a balanced set of metrics covering safety, people, customer service, cost, and asset management?</td>
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<tr>
<th><strong>People</strong></th>
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<tbody>
<tr>
<td>24. Do you have a complete talent management process in place for your DC organization including the five elements of: assess, identify, hire, develop, and retain.</td>
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<tr>
<th><strong>Sustainability</strong></th>
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<tbody>
<tr>
<td>25. Do you have an environmental strategy in place for your DC operations?</td>
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<table>
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<tr>
<th><strong>Total Points</strong></th>
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<tbody>
<tr>
<td>How did you do?</td>
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**0-100 points:** Your DC operation is deficient. You should benchmark best in class operations and develop a multi-year plan to upgrade your operation.

**100-150 points:** You have an average DC operation. You have a solid position to build on. You now need a multi-year plan to improve your DC operations.

**150-200 points:** You have a good to excellent DC operation. Build on your many strengths. But also honestly assess and address your weaknesses.

**200+ points:** You have an outstanding, approaching world-class DC operation. Make sure you keep it that way. Everyone is raising the bar everyday. Keep challenging yourself to remain at the top.
A FINAL NOTE

We hope you have found the material in this white paper helpful and useful. We at the University of Tennessee are committed to translating our No.1 position in academic research into information useful for practitioners. We believe the real world of industry is our laboratory. It’s why we have the largest Supply Chain Forum in the academic world, with over 50 sponsoring companies. We are always looking for industry partners to assist us in this journey. Let us know if you are interested in being one of our valued partners.

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