76

Level Loading and Cross Docking in a Global Logistics Network

By

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Bachelor of Science in Manufacturing Engineering, Brigham Young University (2001)

Submitted to the Department of Mechanical Engineering and the
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In Partial Fulfillment of the Requirements for the Degrees of

Master of Business Administration

and

Master of Science in Mechanical Engineering

In Conjunction with the Leaders for Manufacturing Program at the
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Abstract

There are various reasons why companies manufacture their goods in different areas of the world. These reasons include: lower labor costs, emerging markets, tax and tariff considerations, and intellectual property issues. With the constant pressure to decrease costs, outsourcing is becoming more popular, especially to areas having very low labor costs, such as Asia. As a result of the longer distances needed to ship product, logistics is becoming a much larger part of the cost of goods. The global nature of some businesses also requires long supply chains. This globalization requires firms to manufacture their goods and provide their services throughout the world. The logistics systems can affect the supply chain and operations in many ways. In order to have the lowest overall cost, companies must consider tradeoffs among various cost drivers. Inventory policies and operations might have to be altered to accommodate increased logistical needs. Today, the many details involved in the logistics network have created new sets of problems that have not been as important to firms in the past. This thesis looks at examples of cross docking and leveling as means to reduce the overall supply chain costs in a global logistics network and applying them at Eastman Kodak Company.

This thesis is the result of work done during a 6.5 month LFM internship at Eastman Kodak Company in Rochester, New York.

In order to protect company confidentiality, the data has been altered or disguised.

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Table of Contents

List of Figures, Tables, and Equations

Chapter 1 Introduction and Overview

1.0 Introduction

There are various reasons why companies manufacture their goods in different areas of the world. These reasons include: lower labor costs, emerging markets, tax and tariff considerations, and intellectual property issues. With the constant pressure to decrease costs, outsourcing is becoming more popular, especially to areas having very low labor costs, such as Asia. As a result of the longer distances needed to ship product, logistics is becoming a much larger part of the cost of goods. The global nature of some businesses also requires long supply chains. This globalization requires firms to manufacture their goods and provide their services throughout the world. The logistics systems can affect the supply chain and operations in many ways. In order to have the lowest overall cost, companies must consider tradeoffs among various cost drivers. Inventory policies and operations might have to be altered to accommodate for increased logistical needs. Today, the many details involved in the logistics network have created new sets of problems that have not been as important to firms in the past. This thesis looks at examples of cross docking and leveling as means to reduce the overall supply chain costs at Eastman Kodak Company.

1.1 Background

Eastman Kodak Company (Kodak) is a manufacturer of many imaging products. These products range from film and paper (traditional products), to digital cameras and health imaging equipment (such as X-rays and image storage devices). For a very long time, Kodak earned very high margins on their traditional products of film and paper; in fact, they produced cameras primarily because it helped to sell the film. Kodak has had a lot of strategic challenges to its business in past years. In the 1980s Fuji (a Japanese competitor) was able to get a foothold in the US market and sold the traditional products at a lower price point than Kodak's products. This new competition was only the beginning of the pressures that Kodak would face. In the late 20th century, digital products began to be widely used instead of the traditional products. With the proliferation of digital products, the demand for the traditional products has been in drastic decline. Customers soon had flexibility in deciding which pictures they wanted in hard copy form, instead of having to develop a whole roll of film and they could view and transmit these images electronically instead of sending hard copy prints by mail. Now Kodak is faced with a declining volume (as well as declining margins) on their traditional products and is transitioning into a digital world. The way that the company was run when their traditional products were in high demand is very different than the way the company needs to run in a fast-moving, highly dynamic world of digital products. The company is undergoing a significant strategic change that will affect everything that they do. The products will have shorter life cycles, lower margins, and different competition than the traditional products. Kodak's strategy is to cut costs ahead of declines. Kodak's 2003 annual report states "Kodak took aggressive steps in 2003 to remake itself into a leaner, stronger, more diversified company as fundamental structural change continued to reshape the global imaging industry" [Eastman Kodak Company, 2003]. This transition has caused Kodak to adopt many cost-cutting measures to both extract as much value as possible from the traditional products and allow it to compete in an industry with low and continuously shrinking margins. Kodak has created the Kodak Operating System (KOS) that is fashioned after the Toyota Production System (TPS) as the operating philosophy to help achieve the lowest cost structure as possible by eliminating waste and by making operations a part of the company strategy.

1.2 Organizational Structure

Kodak has an organizational structure that is based upon business units (BUs) that have certain products in their portfolios and that share resources that are used by many of the other business units within the company. Global Manufacturing and Logistics (GM&L) is the largest shared resource. Due to the high capital costs of equipment, it is logical that manufacturing would be a shared resource. Global Logistics is an organization within GM&L that was formed a few years ago in order to centralize the logistics functions and find synergies that can improve the performance and costs of the logistics network for Kodak. Previous to this new organization, each region ran their own logistics, and today, Global Logistics is working to bring the entire company together in its logistics policies and operations. The fact that the various regions ran their own logistics created several different systems and processes. Many of these different processes are used to accomplish the same goal.

1.2.1 Global Logistics Strategy Group

The Global Logistics Strategy Group is one part of the Global Logistics Group. Their charter is to provide the logistics-related strategy in the short to medium term. Many of the projects that they work on have time frames from that last from one to five years. The work done for this thesis took place within this group and drew from many resources of the group. Other projects that take place in the group are: pipeline visibility, RFID implementation, network analysis and implementation, and lead-time improvements.

1.3 KOS

The focus of KOS is to eliminate waste from Kodak's value stream. Waste is anything that does not add value from the customer's perspective. The forms of waste are as follows [Standard, 1990]:

1. Overproduction
2. Inventory
3. Defects
4. Processing
5. Motion
6. Waiting Time
7. Transportation
8. Unrealized Human Potential

Ironically, transportation (Logistics' charter!) is considered waste. An important part of KOS is to realize where the firm is and where the firm wishes to go. KOS is a journey and it is the journey that is important—to focus on continuously improving the current state—no matter how far from perfect it might be at the present time. There are many things that KOS tries to do to reduce or eliminate waste. Reaching for small lot sizes, higher frequencies, leveled loads, short lead times, standardized work, etc., are things that can be done to reduce waste in the system.

1.4 Problem Statement

Kodak's current product portfolio is under a lot of cost pressure. The traditional products are facing shrinking margins and declining volumes. The new digital products are faced with small margins and short product lives but increasing volumes. The fact that many traditional production plants are being closed and that new digital product manufacturing facilities are being built in Asia has lengthened the supply chain for Kodak and made it critical to place an emphasis on logistics costs. Kodak needs to make strides in reducing the overall cost of its logistics network. Logistics consolidation (via cross docking) and load leveling offer promising potential for cost savings in the network. The balance of this thesis will introduce and examine the benefits and difficulties of cross docking and leveling and show applications in regional areas (such as from Kodak Park) and apply the same analysis to a proposed facility that would be a series of two leveled cross docks (one local and one on the West Coast) and what the marginal benefits and costs of this proposal. The criteria for assessing improvements are based on financial impacts of changes. The main drivers are inventory changes (from lane consolidation, lead-time improvements, and demand-variation reductions), transportation costs (based on container utilizations), labor, and one time-costs, such as information technology (IT) upgrade costs. The different scenarios will have different impacts on the various cost drivers.

Leveling will be included because Kodak has adopted it as its operating philosophy, so the effects of this inclusion will also be analyzed.

1.5 Thesis Outline

This thesis is organized into seven chapters.

Chapter 1 contains an introduction to Kodak and the issues that the firm is facing.

Chapter 2 looks at the current state of Kodak's global logistics network and explains some of the terms used in logistics.

Chapter 3 includes an introduction to cross docking. Examples of cross docks are included of both "less-than" truckload logistics providers and an inbound cross dock that Kodak has implemented. The various benefits of cross docking are examined, including examples from Kodak.

Chapter 4 introduces the concept of leveling from KOS. It discusses how it is done and lists the benefits.

Chapter 5 discusses the concept of a leveled cross dock. An example of how Transfreight (Toyota's logistics provider) runs its cross dock is discussed.

Chapter 6 contains an explanation of a proposed project by Kodak for a leveled cross dock that is in series with another leveled cross dock. The benefits of the proposal will include concepts discussed in earlier chapters.

Chapter 7 includes the recommendations and discusses the analysis performed. This chapter will also contain lessons learned from the experience.

Chapter 2 Current State

2.0 Current State

Kodak's current supply chain is very large and complex. The traditional products have several processing steps. Some of these steps are base manufacturing, sensitizing, slitting/perforating, and packaging. Due to various factors such as duties, tax structures and incentives, and intellectual property (IP) considerations, some of the manufacturing is done within the U.S., and some is done globally. It is expected that demand, especially for traditional products, will be mostly outside of the U.S. In some cases, the product base is manufactured in the U.S., sensitized in another country, and slit/perforated in yet another country. It is then packaged and sometimes returned to the same country in which the base was manufactured. This is an extreme example of the global nature of Kodak's supply chain. With long supply chains, logistics is a very large part of the supply chain activity. The decline in demand is forcing Kodak to close some of its plants to consolidate capacity and to keep plant utilization high; this causes the supply chain to lengthen. Even newer digital products have fairly lengthy supply chains, with a lot of manufacturing done in the Asia region and shipped throughout the world. In most cases, products spend a significantly larger part of the time in transit than in any manufacturing process. The logistics networks add a lot of time and delay, as well as higher costs and more complications.

2.1 Supply Chain Structure

Kodak has decided to split its supply chain into three distinct parts (or "spaces") as follows: Supplier-to-Kodak, Kodak-to-Kodak, and Kodak-to-Customer. Due to strategic reasons, operating in each of these segments is different for Kodak. The Supplier-to-Kodak space defines the relationships and products that Kodak's suppliers deliver to Kodak. These products range from water and chemicals to electronics. Many of these items are commodities, thus there are several suppliers for the same item, which gives Kodak the strategic power in the relationships. Kodak has influence over its suppliers because most of them are commodity-type items in which the suppliers can compete with each other, based on price. The Kodak-to-Kodak space is all material that flows from a Kodak-owned facility to another Kodak-owned facility. It involves everything from goods that flow between manufacturing units and out to distribution centers. The advantage of this space is that Kodak owns both ends of it and can make various tradeoffs. In the Kodak-to-Kodak space, the corporation can find and implement policies that have global optimums, instead of favoring one end or the other. The Kodak-to-Customer is the space between the distribution centers and the customers. The customers are retailers that include Wal-Mart, Kmart, Costco, etc. This is the area in which Kodak has the least strategic power. Kodak has several competitors that offer similar products, and the customers (at least the large ones) make compete Kodak with its other suppliers, and the customers focus on price.

2.2 Logistics Network Terms and Definitions

It will be useful to explain some parts of the distribution network and some logistics terms in order to facilitate the discussion throughout the thesis.

2.2.1 Container

A container is a vessel that is used for overseas shipping. The capacity (by weight) of a container is approximately 40,000 lb. A container is essentially a rectangular metal box that holds cargo there is also a chassis (which has wheels on it) that connects to the container and allows the container to be shipped by truck. This chassis is removed before the container is loaded onto the ship.

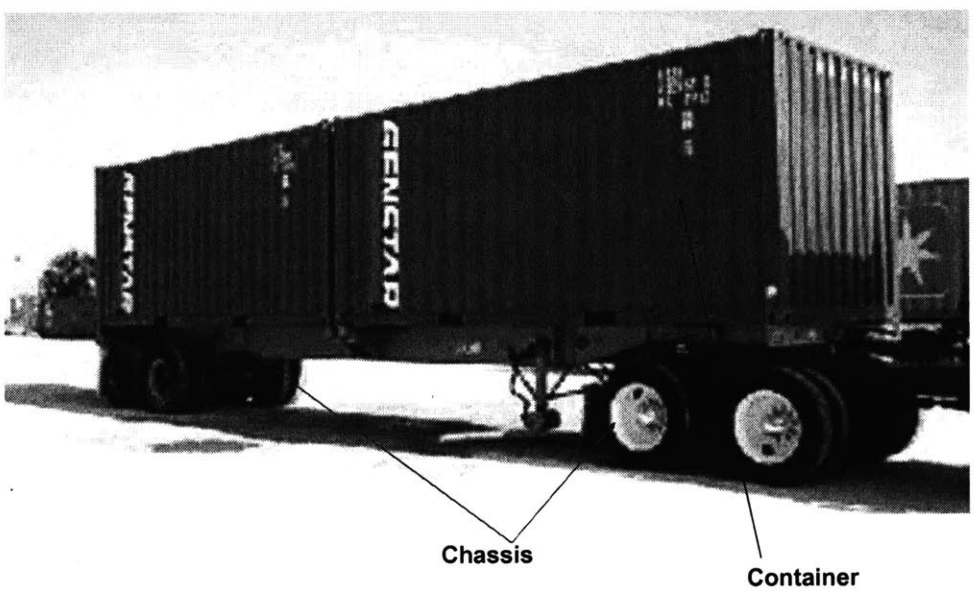


Figure 1 Picture of a container on a chassis
(http://www.bttinc.com/chassisTypes.asp)

2.2.2 Trailer

A trailer is a vessel similar to a container, except the trailer is strictly for travel land. There is no additional chassis for trailers (the wheels are permanently attached to the cargo box). Trailers are very commonly seen on highways. The weight capacity of trailers is roughly 45,000 lb.

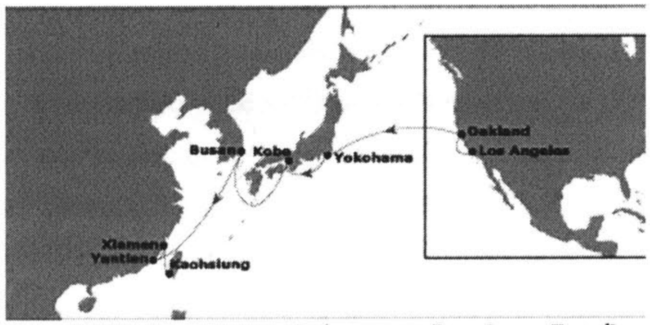
Figure 2 Picture of a truck and trailer
(http://www.hankstruckpictures.com/morton14.htm)

2.2.3 Lanes

A lane is a path along which goods are sent. It is the path between one shipping point at the origin and one shipping point at the destination. Each lane can operate differently and independently of the others. It is also important to note that lanes are directional, especially when considering operating policy. For example, the lane between the Kodak Park and Xiamen may operate differently going in one direction than in the other direction. This can be attributed to volumes of material heading in each direction, which affects the shipping costs and frequencies. For example, the cost of shipping a trailer from the West Coast to the East Coast can be four times the cost of shipping in the other direction. Another reason for the directional properties is due to the value of the goods going in each direction. In this case, the goods going from Kodak Park to Xiamen are much less valuable (film base, paper, etc.) than the goods traveling the other direction (finished and packaged film, digital cameras, etc).

2.2.4 Shipping Frequencies

Generally, most lanes are said to have a sailing frequency of once per week. This does not mean that there is only one boat per week that leaves the West Coast for the Asia region. Many of the lanes have port rotations. Figure 3 (Maersk Sealand's website) shows an example of port rotations. If there is a container that has to leave Los Angeles and is bound for Xiamen, it must first go through Oakland, Yokohama, Kobe, Busan, and Yantian before it reaches Xiamen. Each port takes roughly an additional half-day to whole day of time. Kodak tries to find the routes that are on the last domestic port rotation before shipping overseas, and the first port when it arrives at its foreign location. This allows for the shortest lead-time option and usually leaves once a week. There are some lanes that different carriers might have similar rotations in which the shipping frequency is twice a week or more.



Port	Arrives		Departs		Transit
Los Angeles, CA	Tue	1800	Thu	1800	--
Oakland, CA	Fri	1800	Sat	0800	1
Yokohama, JAPAN	Tue	1800	Wed	0400	11
Kobe, JAPAN	Thu	0800	Thu	1800	12
Busan, S.KOREA	Sat	0900	Sat	1600	15
Yantian, PRC	Tue	0600	Wed	0200	18
Xiamen, PRC	Wed	2000	Thu	0600	19
Kaohsiung, TAIWAN	Thu	1700	Fri	0500	20

Figure 3 Example of port rotations [Maersk website]

2.2.5 Utilization

Container utilization can be measured several ways. It can be measured by the amount of floor space in the trailer or container that is already I use. For example, a container that has floor space for 20 pallets and has15 pallets loaded onto it has 75% utilization, even though there might be extra volume space available and/or the container can hold more weight. Utilization can also be measured in terms of volume. Containers have a cubic volume limit, and the load placed in the container takes up a percentage of this volume, which can be given a utilization metric. This metric is hard to track because data on the loads is difficult to obtain, and often the data associated with the material volume is inaccurate. The last method of measuring utilization (and the one that will be used throughout this paper) is utilization by weight. A container can hold approximately 40,000 lb of material. If 20,000 lb of material is loaded onto a container, then the utilization is 50%. Utilization by weight is the easiest to obtain because all of the loads have to be weighed because balance and weight capacity requirements. Ideally, every container should be fully loaded in terms of both volume and weight, but most items that Kodak ships “weigh out” before they “cube out” or exceed the volume capacity of the container.

2.3 Current Export Fulfillment Process

For this thesis, the export business is considered to be everything that is shipped from one of Kodak's domestic sites in Rochester, NY; White City, OR; and Windsor, CO, to Asia, Japan, and Australia. The current process for the export business is the following:

1. An order from one Kodak facility is placed on another Kodak facility.
2. A transportation planner watches the accumulated orders for a destination and when the total reaches 40,000 lb, the "tickets" are sent to a set of printers for pick up. It is important to note that when the deadline for making the weekly shipment arrives, the transportation planner must make some decisions. If the total remaining product is greater than 9,000 lb, the planner is free to send the material, even though the container is less that 25% utilized. If the remaining product is less than 9,000 lb, the planner contacts the business unit, and the material is usually shipped by air. Some of the justification for this is that the air shipment can be less than, or comparable to, the cost of overseas shipping. Air shipments are on a variable-cost basis, thus there is a direct cost-per-pound to ship. Shipping via containers is a fixed-cost situation. It is a fixed cost to send a container to a destination; so ideally, if there is more material on the container, the cost per pound goes down.
3. The tickets are printed in batches and they are brought back to the dock area.
4. The pickers distribute the tickets among each other and go out through the warehouse, pulling the materials and put them into staging lanes by the dock.
5. The system is updated and the staged lane is updated to a "ready for loading" status.
6. The container is loaded
7. Information about the load is sent to the export office where the paperwork and carriers are assigned.
8. The container is pulled out to the yard and picked up by the carrier.
9. The container is put on a train or it is trucked to a port, at which point the container waits to be loaded onto a boat. Material that has Rochester as an origin is trucked to New Jersey and either placed on a boat and sent to the destination (Asia, Japan, or Australia) or put on a train and shipped to the west coast to be loaded on a boat and shipped to the destination.

Table 1 shows an example of the container utilizations (by weight) under the current process.

Japan	92%
Australia	63%
GCR	82%
Taiwan	51%
Hong Kong	69%
South Korea	82%

Table 1 Sample container utilizations by destination

One can look at the utilization and realize that there is potential for improvement. When utilizations are improved, the number of containers required for shipping material decreases, which causes decrease in transportation costs for Kodak. However, it might also cause increased inventory requirements if the utilization is achieved by reducing the frequency of shipments.

2.4 Lane Proliferation

As discussed in Chapter 1, each region used to operate its own logistics. Each building that has manufacturing facilities would load the containers and send them directly to the destinations. There are many buildings located at Kodak Park (located in Rochester, NY), but they have separate shipping points. The same is true (to a lesser extent) of other Kodak facilities. Figure 4 shows an example of this proliferation. Assume that there are 5 shipping points within Kodak Park and 3 shipping points in Xiamen, there are 15 (5*3 = 15) lanes that have been created due to each region running its own logistics.

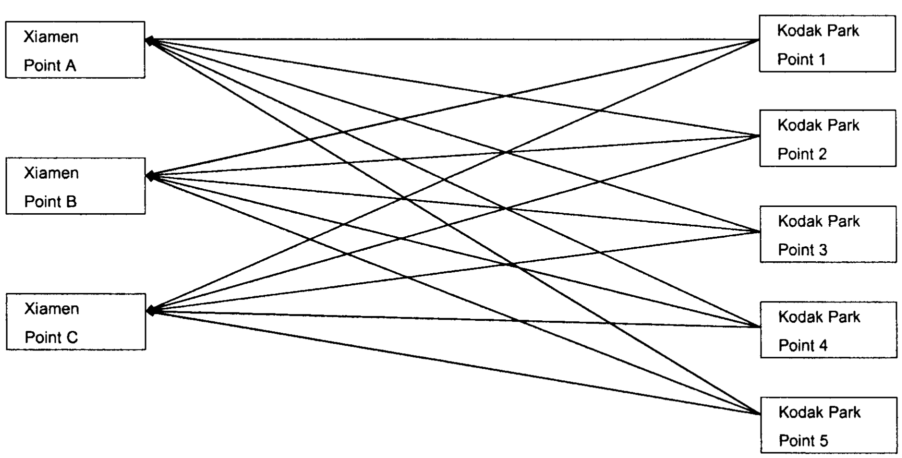


Figure 4 Example of current state of lanes with separate shipping points

Even though all of the products essentially move between Kodak Park and Xiamen China, there are many lanes. If the lanes can be consolidated, there is a great potential for savings. Currently, the lanes are not consolidated because they are run independently by the business units, not by a central logistics group.

2.5 Summary

Kodak has been experiencing a lot of change in its business environment. Demand for traditional products has been declining and Kodak has consolidated some of its worldwide capacity. These changes have resulted in a need for change in the operation of the global logistics network. There might be an opportunity for costs savings with the increased utilization and consolidation of lanes. These approaches will be discussed in the next few chapters.

Chapter 3 Cross Docking

3.1 Cross Docking

"Cross docking means to take a finished good from the manufacturing plant and deliver it directly to the customer with little or no handling in between." [CVOC website]. Figure 5 shows an example of how a cross dock works. The inbound freight comes in on one side, the trailers are unloaded, and the material is either placed into staging lanes according to destination, or it is loaded directly onto the trailers on the outbound side. There are two types of cross docks: schedule-driven, which assures a high service level, but risks low trailer utilization, and load driven, which assures the highest trailer utilization, but risks low service levels [Ratliffe, 1999]. In reality, the applications in this thesis are based on logistics consolidation, and cross docking is a means to, or an enabler of, logistics consolidation.

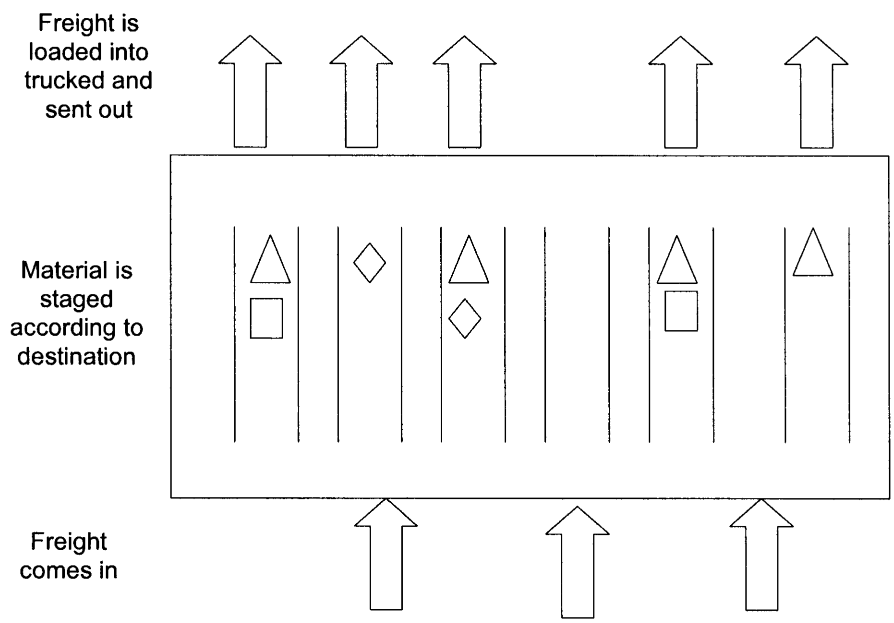


Figure 5 Sample cross dock

3.2 LTL Carriers

Many third-party logistics providers, such as Yellow Roadway Corporation (Yellow), run less than truckload (LTL) freight transportation. In logistics, the cost of sending a trailer between two points is essentially a fixed cost. That is, when a firm sends a trailer between two points, it costs the company a fixed amount, regardless if there is one pallet on the trailer or if it is packed to capacity. In the event that a company has an LTL load, it is many times more economical for them to send it via an LTL carrier. The LTL carrier takes the load and combines it with several other LTL loads bound for the same destination to get full trailers, and thus, the average cost per pound for the LTL carrier is much lower than the average cost per pound for the firm to send the LTL load. LTL carriers make money by maximizing the utilization between the nodes in their networks and by taking advantage of economies of scale.

3.3 LTL Cross Dock

LTL networks are basically hub-and-spoke operation, similar to those of the airlines. Each "hub" is a cross dock. One example of an LTL cross dock Yellow that runs in Buffalo, NY. Each morning, Yellow receives many pick up requests from the surrounding areas; they are told the weight of the material and the number of pallets. Trucks are dispatched to various locations that are somewhat close to the cross dock. The regions are relatively small; therefore, the transportation costs are not a major concern. The trucks pick up many LTL loads in the area that will flow through the cross dock (they do not all have to be bound for the same destination). The material from these routes are brought to the cross dock and unloaded. As the material is unloaded, it is sorted by destination. While the facilities have some room for storing material, most of the material is unloaded from one trailer on the inbound side and is loaded directly onto another trailer on the outbound side. The most important metric for the LTL carriers is utilization. They want to maximize the weight that goes onto each trailer so they can amortize the fixed cost of the transportation over as much weight as possible, achieving the lowest cost per pound.

3.4 Kodak's Inbound Cross Dock

In the Supplier-to-Kodak supply chain space, Kodak has worked with some regional suppliers to implement an inbound cross dock. Kodak has taken on the cost of transportation in order to get the suppliers to agree to this new arrangement. Currently, Kodak is working with suppliers that are within a one-day drive from Kodak Park. Each day, the planner responsible for the cross dock receives orders from the various manufacturing areas. The planner plans all of the routes and scheduling for the cross dock that day. He sends information to the carriers to let them know what they are to pick up and where, as well as their scheduled arrival time at Kodak Park. The planner also posts the route schedule that is internal to Kodak Park. This planning activity is delivered to the truck loading detail. Each truck has a plan for the position of each different material within is it container. Due to the fact that the orders vary each day, the planning activity is a daily event and takes a few hours for the planner to complete. Kodak has been able to reduce its raw materials inventory because of the daily deliveries of raw materials. This reduction can be seen from the base stock model (Equation 1), the review period is reduced to one, thus lowering the total inventory requirement.

3.4.1 Potential Issues

Kodak wishes to scale up inbound cross docking (by including suppliers located in regions farther out from Kodak Park) because there has been a reduction in inventory, so the logic follows that if the operation is scaled up, the benefits will also scale up. There are some potential issues that might arise with the scaling up of this operation. First of all, as the number of suppliers is expanded, the workload of the transportation planner increases dramatically. The complexity of the planning role becomes more difficult, with more players involved, and with the transportation time being longer on some routes. Also, at the cross dock, the employees look at utilization as the percentage of the used floor space on a trailer. So, if the trailer has 20 pallets worth of floor space and a trailer has 14 pallets on it, they consider the trailer to be 70% utilized. The utilization is not as much of an issue with the suppliers that are relatively close; but as the network is expanded, the full trailer utilization (by weight) becomes more of an issue. Kodak also needs to be firm on price reductions for the materials. Because Kodak is now paying for the transportation, the cost of the goods should go down. The bottom line is that a relentless focus on inventory levels should not blur the total cost picture.

3.5 Advantages of Cross Docking

There are several advantages of cross docking. Some of the advantages are unique to a firm in Kodak's position where they own both the origin and destination. Kodak can make some tradeoffs to optimize overall cost and service level by owning both sides of the chain.

3.5.1 Base Stock Model

In order to provide a framework around some of the benefits, it is important to look at the inventory policy that is used in many parts of the network. This model is the Base Stock Model (Equation 1) as outlined by Kaminski, Simchi-Levi, and Simchi-Levi [2003]:

$$B = (r + L) * AVG + z * STD * \sqrt{(r + L)}$$

Equation 1 Base stock model

Where:

B = Base Stock Level or "order up to" level of inventory

r = Review Period

L = Lead Time

AVG = Average Lead Time

z = Safety Factor

STD = Standard Deviation of Demand

This inventory model sets a target inventory for a location. Every review period the inventory level is checked and an order is placed that would bring the inventory position back up to the base stock level. This policy covers for both the lead time demand and the fluctuations in demand from the average. There are a few things that can be done to decrease lead time, but these usually incur a large cost such as flying the material instead of shipping by ocean.

3.5.2 KOS Principles

KOS tries to achieve many goals in its effort to have the lowest possible operating costs. KOS believes in quick changeovers, small lot sizes, and high frequency of parts being moved in a mixed fashion. KOS tries to eliminate waste by: reducing lot sizes, having higher frequency movements, using visual systems, etc.; and cross docking can help achieve some of these objectives, which will be discussed in the next few paragraphs of this chapter.

3.5.3 Network Simplification

One of the advantages of cross docking in Kodak's logistics network that is the easiest to visualize is that of network simplification. All of the shipping points at the origin are consolidated into one, and all of the destination shipping points are also consolidated into one. An example is shown in Figure 6 and Figure 7. In Figure 6, there are 5 shipping points in Kodak Park and 3 in Xiamen (which creates 15 lanes).

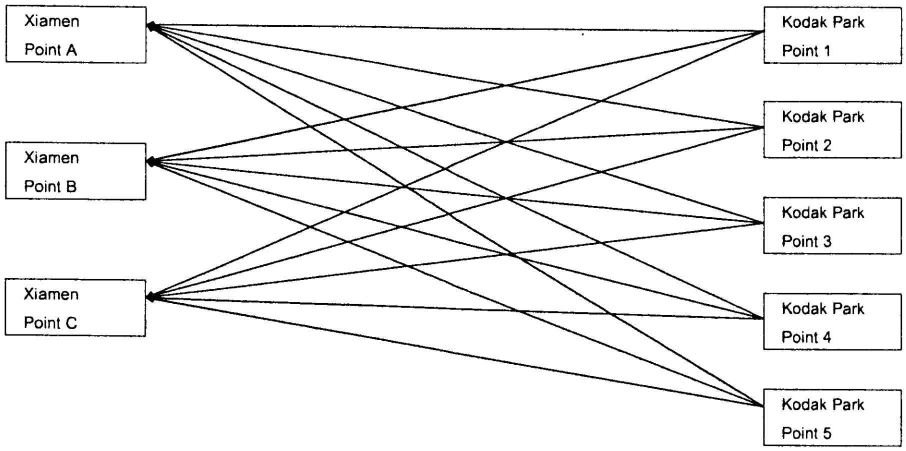


Figure 6 Example of current state of network with separate shipping points

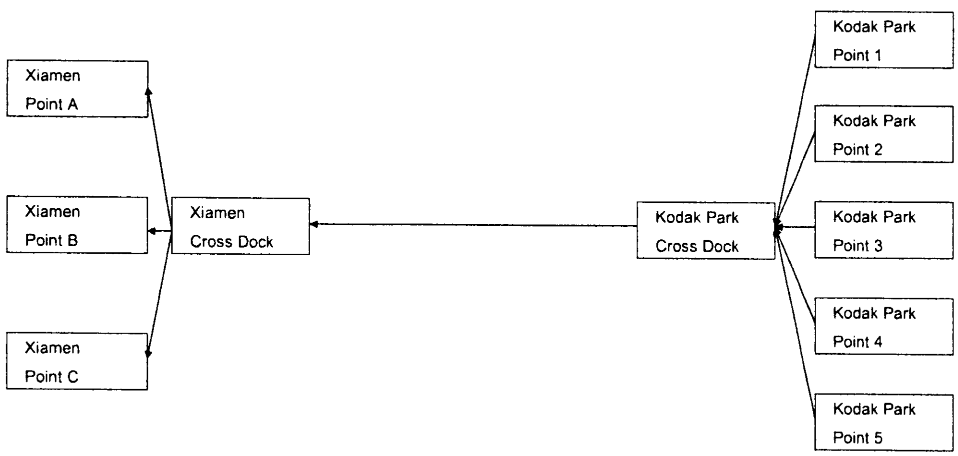


Figure 7 Consolidated lanes

Figure 7 shows that when the lanes are consolidated through cross docking, there is now one shipping point, each in Kodak Park and Xiamen, which brings the number of lanes from 15 to one. The distances between the local buildings and the cross docks are very short, thus the cost of transportation is negligible for these short distances.

3.5.4 Systems Consolidation

Because of the fact that each BU ran their own logistics, there are some legacy systems that still exist. Now that Global Logistics is consolidating all of the logistics efforts, the systems can be consolidated into one. This cuts down on training and maintenance costs and allows more flexibility in the workforce because everyone will use the same system, and every employee can do the same job in Currently, many of the loads that leave Kodak Park (except for those leaving the central distribution center) have one type of product on it. That means that each time a destination receives a load, it has a large lot size of the product (at times a full container). When the lanes are consolidated, each load that is shipped will have a mix of items. Thus, the lot size is effectively reduced. Now, instead of receiving an entire container of the same product, each container will have a few pallets of many different goods on it. Now each product will be shipped more frequently, for example, instead of sending 6 pallets every 6 weeks, 1 pallet will be shipped each week.

3.5.5 Reduction in Effective Lot Size

Currently, many of the loads that leave Kodak Park (except for those leaving the central distribution center) have one type of product on it. That means that each time a destination receives a load, it has a large lot size of the product (at times a full container). When the lanes are consolidated, each load that is shipped will have a mix of items. Thus, the lot size is effectively reduced. Now, instead of receiving an entire container of the same product, each container will have a few pallets of many different goods on it. Now each product will be shipped more frequently, for example, instead of sending 6 pallets every 6 weeks, 1 pallet will be shipped each week.

3.5.6 Increased Utilization

Another potential benefit of cross docking is the possibility of improved utilization of shipping containers. In some of the current lanes, the containers "weigh out" before they "cube out." In this situation, if a few of the pallets of the dense items could be removed and several pallets of lower density items can be placed in the container, the utilization of the container will be improved. A simplified example is as follows: suppose there are 6 extremely dense items called Product A and 6 extremely low density items called product B, A is so dense that only 3 of them can be placed on a container before it weighs out, and B has such low density that only 3 of them can be placed on a container before it "cubes out." To send all 12 items, a planner can load 3 As, each, into 2 containers and 3 Bs, each, into 2 more containers. This means that it takes 4 containers to send all 12 items. If the goods were mixed, a planner could potentially place 2 As and 2Bs into each of 3 containers. Due to the mixing, the same items can be sent in 3 containers instead of 4. The only way that the improved utilization can happen is if all of the goods bound for the same location are loaded at the same point. As stated earlier, currently, all of the As are manufactured and loaded in one building and all of the Bs are manufactured and loaded in another building. It is important to note that utilization can only be increased if there is sufficient material to load. If there is some operational process that sends containers before enough material arrives to fill them, the utilizations will be unaffected.

3.5.7 Decreased Lead Time

The possibility of decreased lead time only exists in a load driven cross dock system. In a load driven cross dock, the goods are only shipped when there is a full container or some predetermined amount of material ready to ship. There is, in effect, an "accumulation time" component of total lead time, which is shown in Equation 2.

$$Acc = Cutoff \,/\, Avg$$

Equation 2 Accumulation time

Where:

Acc = accumulation time

Avg = Average Demand (lbs/day)

Cutoff = a predetermined load at which time a container or trailer will be loaded and shipped (lbs)

If there is a policy that every container is sent only when there is 40k lb ready to be shipped, and the average demand for a product is low, the accumulation time can get quite large. In a cross dock, the average demand is not just for a single product but also for all products bound for the same destination. The slow-moving items are, in effect, subsidized by the faster moving items. This allows a higher frequency of shipments along, with the smaller batch sizes discussed earlier.

3.5.8 Reduced Inventory Due to Batching

The fact that the goods move in batches that are essentially the container size means that inventory has to be added to the system to allow it to function smoothly. This is illustrated in Figure 8. Each triangle is a single item and is sent to meet the demand of 1 triangle per day (assuming no demand variation). If there is no lead time, then 1 triangle is produced by the manufacturer each day and 1 triangle is consumed by the customer each day, so there is essentially no inventory held in the system.

If the lead time is 7 days, then 1 triangle is produced and sent by the manufacturer each day and 1 triangle arrives to the customer and is consumed, thus there are 7 triangles worth of inventory in the lane (as shown at the top of Figure 8). Each square represents a batch of 3 triangles. When the "batches" are introduced, inventory needs to be added. There are 9 triangles worth of inventory in the batched system (as shown at the bottom of Figure 8). This snapshot will be called "day 1"

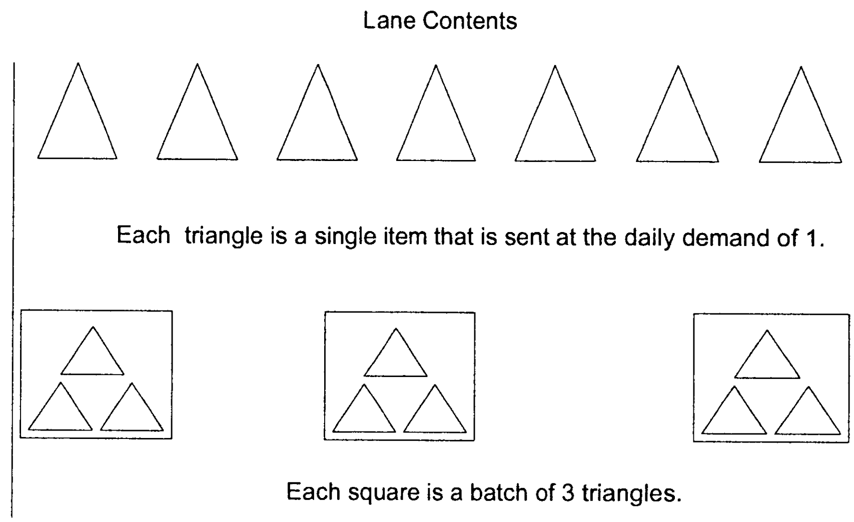


Figure 8 Sample of inventory in lane "day 1"

As "day 2" comes around, the manufacturer produces 1 triangle and holds it (while waiting for a batch to accumulate before sending), and the first batch arrives at the customer and 1 triangle is consumed while the other 2 are stored, this is shown in Figure 9.

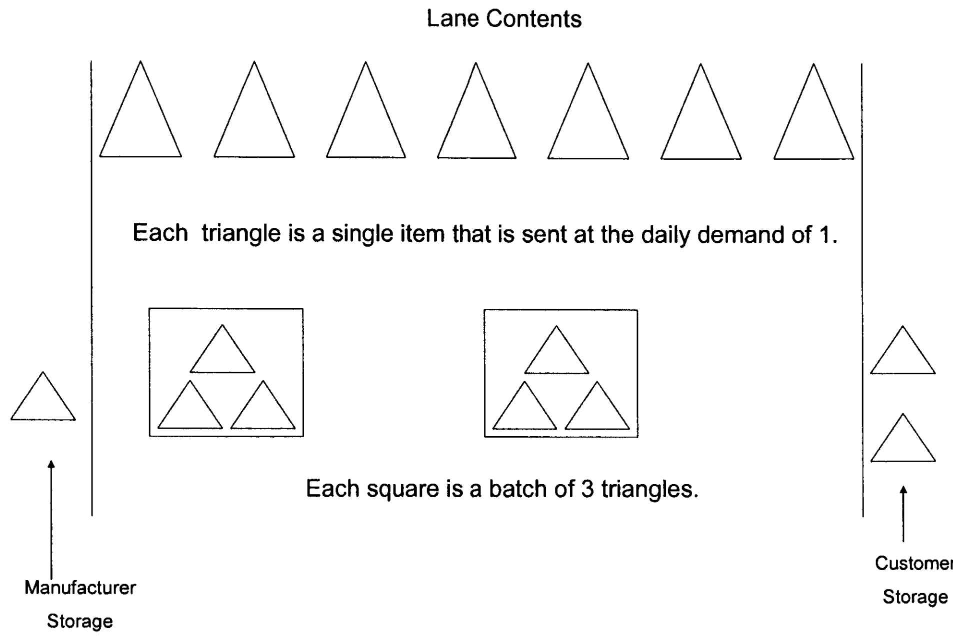


Figure 9 Sample of inventory in lane "day 2"

As "day 3" rolls around, the manufacturer produces another triangle and stores it (still waiting for a batch to accumulate) and the customer consumes one of the triangles that it was holding. This can be seen in Figure 10.

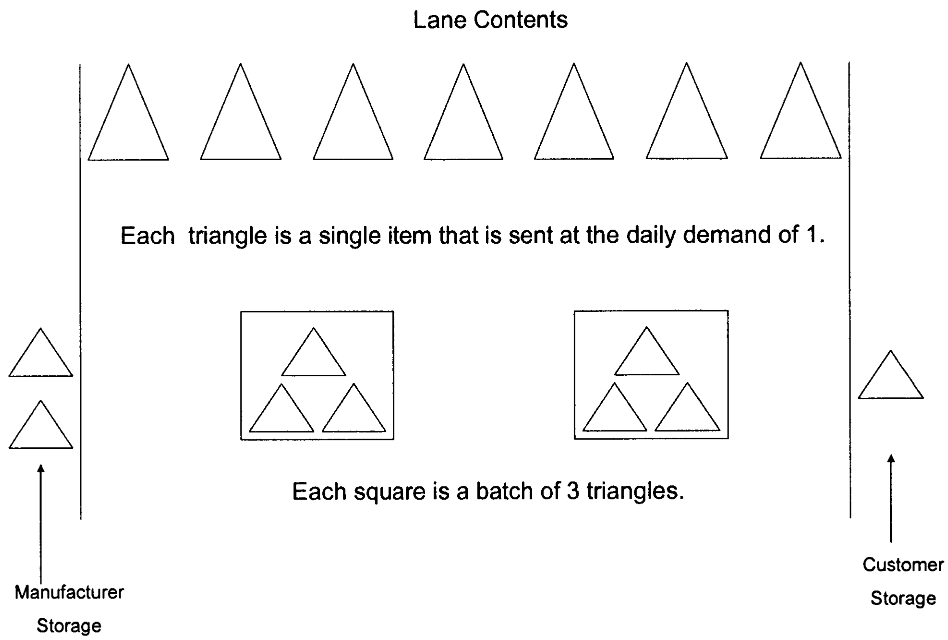


Figure 10 Sample of inventory in lane "day 3"

As the next day comes around, the manufacturer produces another triangle and sends the full batch. The customer consumes the last triangle that it was holding and the system returns to what it looked like on "day 1" shown in Figure 8. The system that didn't have batching always had 7 triangles in the system with essentially no triangles at the manufacturer or the customer since they either ship it when it's made or consume it on arrival. It's interesting to note that both systems have an average of 7 units in the lane. The batched system has 9 triangles in the lane the first day, 6 triangles in the lane the second day and 6 triangles in the lane on the third day, then the cycle repeats, so the average is 7 triangles in lane. The system with batches always has to have 9 triangles in the system, either in the lane or at the manufacturer's storage or at the customer's storage. The additional inventory required, due to the batching effect, is one *batch* minus *one unit* (in this case, a batch is 3, so 3–1 = 2 additional units of inventory need to be added to the system). Another way of explaining this is shown in Figure 11.

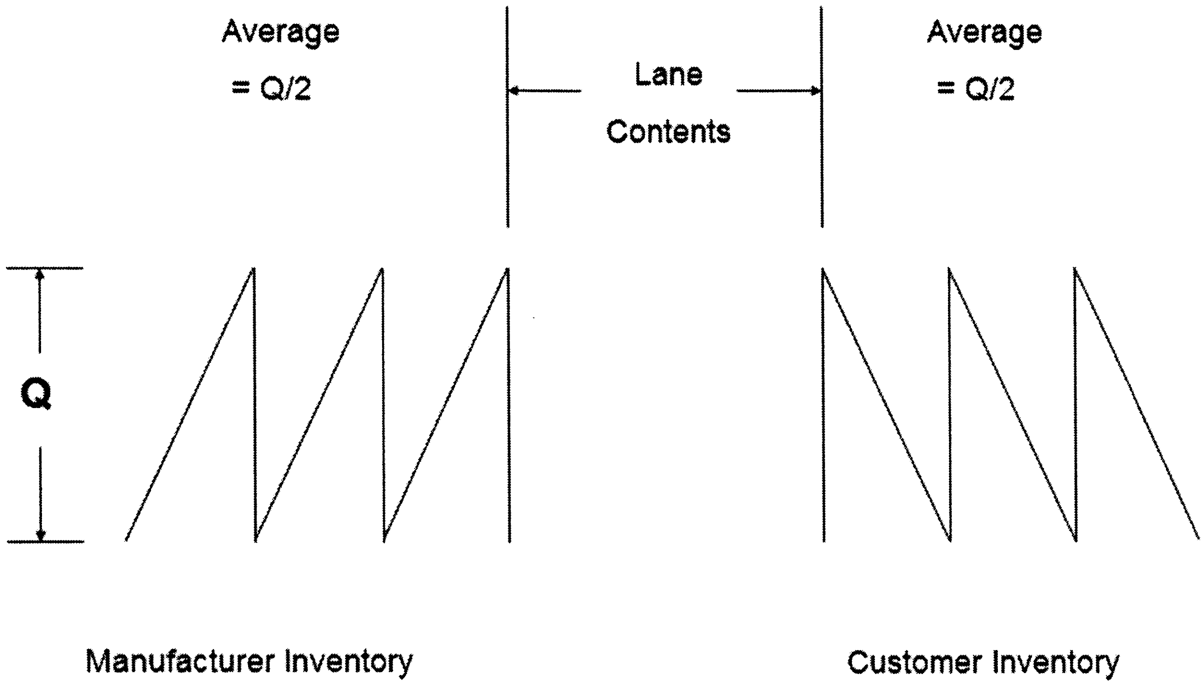


Figure 11 Inventory required for batching

The manufacturer builds 1 unit each day until the batch size "Q" is reached, and the batch is shipped. The customer receives a batch size Q and consumes 1 each day until there's none left, then another batch arrives. The manufacturer and the customer *each* have an average of Q/2 units. The lane contents are the same on average with or without batches. If the batch size is 1 unit, then the additional inventory held by the manufacturer and the customer is 1/2 unit each for a total of 1 unit. If the batch size is 3, then the total inventory held by them is 1.5 units each, for a total of 3 units. The difference between the two scenarios is 2 units (3-1=2). Again, the point is that the additional inventory required is the *batch* size minus 1 *unit*. This is essentially what happens in a logistics network. There are batches in the system that take the form of trailer or container loads. By consolidating the lanes, each lane that is eliminated reduces the required inventory by almost one container (there are 40 pallet positions on each container, thus 40–1 = 39 pallets can be removed from the system), since the inventory reduction is close to a full container, for simplicity sake, it will be assumed that for each lane eliminated, a full container of inventory will be removed from the system.

3.5.9 Reduced Inventory Due to Loading Policy

With a load-driven cross dock, the transportation costs can be minimized by setting the "cut off" for a load to be the capacity of the containers, which is 40k lb. If the cutoff is set at 40k lb, and in a week, 46k lb worth of material are ordered, then 40k lb will be loaded and the remaining 6k lb will wait until another 34k lb is ordered. Thus, the destination will, in essence, be lacking by 6k lb of the expected delivery. If the destinations hold extra inventory to accommodate this potential "shortage," a policy of full containers can be implemented. The most that this shortage can ever be is 39,999 lb, and in fact, it can be refined by examining the distribution of the left over amount and by holding an appropriate amount of inventory, something similar to the analysis done for safety stock in the base stock model, which covers a percentage of the variation in demand. Analysis can be done once data is collected to refine this requirement. It is sufficient to say that the most this will ever be is a full container, and to ensure 100% coverage for no shortfalls resulting from the loading policy, each lane destination needs to hold an extra container's worth of inventory. In fact, if one looks at an average, the safety stock addition will probably only need to be one half a container (20k lb), since it will be short, on average, by one half container. Again, by consolidating the lanes, the amount of extra inventory required to accommodate the policy is drastically reduced. Since each lane requires an additional half container's worth of material, each lane that disappears because of consolidation reduces the required inventory by approximately one half container. Even if the current cutoff of 9k lb is maintained, the extra inventory required per lane would be 4.5k lb on average. Each lane that is consolidated would reduce this requirement by 4.5k lb of inventory to be held at the destinations. Since Kodak doesn't currently add inventory to accommodate this loading policy, savings will largely be ignored in the analysis.

3.6 Cross Dock Analysis

As an example of benefits, the cross dock that is to be set up in Rochester will be analyzed. The system will be material moving from Rochester to seven geographic destinations in Asia, Japan, and Australia. For simplicity, an assumption will be made that there are 3 shipping points in Rochester and 2 shipping points at each of the destinations, which creates 42 lanes (3*2*7 = 42). Reality is a bit more complex with many shipping points in Rochester, but not all of them serve each point at the destinations. As for the one-time costs, such as IT investment, this is zero because there is already a process in the system for cross docking called the "3999 process." There should not be any effect on direct labor costs because the same amount of material is being moved. The transportation cost improvements depend upon the loading cutoff. If the assumption is made that the cutoff remains at the current state, then the utilizations should remain the same, and so there may not be any benefit as far as transportation costs are concerned, except that utilization *may* go up because of the pooling of the load variability. The inventory requirements will decrease due to lane consolidation. Each lane that is removed reduces the inventory requirement by 40k lb (roughly 1 container worth). Assuming that a cross dock is *not* placed at the destinations, the new network has 14 lanes (1*2*7 = 14), achieving a reduction of 28 (42-14=28) lanes. The inventory savings is 1.12M lb (28*40k = 1.12M) of inventory. Assuming a cost of $5/lb, the savings is $5.6M. If the destinations also set up cross docks, the network contains 7 lanes (1*1*7 = 7) achieving a further reduction of 7 (14-7=7) lanes. This additional 7-lane reduction causes a reduction in inventory of 280k lb (40k*7=280k) of inventory and a further savings of $1.4M. The total benefit of the change is $7M ($1.4M+$5.6M=$7M).

The analysis should be extended to find out the benefit of increasing the inventory in the system to accommodate full containers and compare that with the cost of the inventory itself. In order to accommodate full containers according to the loading policy, approximately a half container's worth of material (20k lbs) needs to be added to each of the destinations. With 7 lanes, approximately 140k lbs (7*20k lbs =140k lbs) need to be added to the destinations. The cost of this additional inventory is $700k. To figure out the transportation costs, data was pulled for a one year period, and using the current utilizations and costs to ship each container to the various destinations, the transportation costs for the year would have been $5.31M. If the utilizations were increased to 100%, then the number of containers required decreases and the "new" transportation costs would be $3.98M. While extra inventory to accommodate full utilization costs $700k, the transportation savings is $1.33M ($5.31M-$3.98M = $1.33M), for a net savings of $630k ($1.33M-$700K = $630k). The total savings from consolidation and full utilization is $7.63M ($7M+$630k=$7.63M). This savings will change with transportation costs, so the tradeoff of inventory to transportation costs is even more beneficial in times of high energy costs unless firms have ways to hedge against transportation cost increases. Inventory costs, transportation costs, and number of lanes are the critical factors in the analysis. There will probably also be additional savings from indirect labor which is difficult to quantify and the cost savings will only add to the attractiveness of the project. It is interesting to note that regardless of these factors, there is an inventory savings when lanes are consolidated with no other cost increases, and the savings can be dramatic. In a Net Present Value (NPV) analysis, the inventory savings is a one time cash flow and the transportation savings go out in perpetuity, so the savings presented here are savings in year 1, but the NPV will be higher due to the future transportation savings.

3.7 Summary and Conclusion

Cross docking has many benefits that can be achieved. Many of these achievements are in line with KOS objectives, such as smaller lot sizes, higher frequencies, and mixing of products. There are many benefits that are hard to quantify, such as network simplification and systems consolidation. Many of the benefits, especially those related to inventory improvements, can be quantified. The only change in the current process is that the Kodak local transportation functions have to make frequent milk runs to the various buildings and take the materials to the cross dock. There is currently a process in the IT system already set up for cross docking. Many of the functions of cross docking currently exist and are performed in some manner in the normal loading processes.

Chapter 4 Leveling

4.0 Leveling

One of the intentions behind the Kodak Operating System (KOS) is to place the incentives to drive the right behavior within operations and the supply chain. The purpose is to have the lowest cost of operations by putting have the right product in the right place, at the right time, in the right quantity, with good quality. This is a difficult challenge to meet and to constantly sustain; therefore, the focus is the journey to improvement and to always be aware of the end goal. Since this end goal is practically impossible, it is important to make the improvements that get closest to the goal. Many times, KOS tools and principles attempt to drive the waste to the source and provide incentives for improvement. One of the KOS tools is leveling. In fact, Figure 12 shows how integral leveling (or Heijunka) is to the rest of the KOS philosophy [KOS]. In manufacturing, leveling is done for both volume and product mix.

Figure 12 Heijunka as the foundation of KOS [KOS]

As far as logistics is concerned, what matters is having a leveled volume of material to ship which levels the workload for the logistics operations. Logistics doesn't really get benefit from a leveled product mix, but if manufacturing levels its mix and volume, then the natural outcome is a leveled volume for logistics. This chapter will discuss leveling and the benefits of leveling.

4.1 Heijunka

Heijunka is the Japanese word for leveling out the schedule [Liker, 2004]. According to Jeffrey Liker, "Leveling production means smoothing out the volume and mix of items produced so there is little variation in production from day to day." [2004] One of the foundations of leveling is takt time. Takt time is defined as available time divided by customer demand. For example, if a plant works one 8-hour shift and the customer orders 2 items per day, the takt time is 8 hours/2 items or 4 hours per item. This is the pace at which the plant should be producing the item. Many factories make more than one item, and the scheduling of the many products and many different demand profiles can be quite complicated. Instead of producing large batches of individual items, there are frequent changeovers that allow each product to be made at its takt time. When all of the products are made at their individual takt times, the product mix is leveled. Volume leveling can be done in a couple of ways. First, there are times in which the true customer demand is not highly variable, thus the daily orders can be scheduled at a daily takt time, meaning that each day, the takt times are adjusted for the real demand. Many times, the variability is caused by the batching and communication that takes place along the supply chain that is amplified as it moves up the supply chain causing the bullwhip effect [Fine, 1998]. A firm might also hold manufacturing constant for a period of time, regardless of demand. For example, the firm might set the takt times for some period of time, say 6 weeks, and then after the 6 weeks, the takt times may be adjusted up or down, depending on the realized demand over that time period. Figure 13 shows an example of the supply chain as it currently stands.

Figure 13 Supply chain without leveling [KOS]

Figure 14 shows the same supply chain with the effects of leveling.

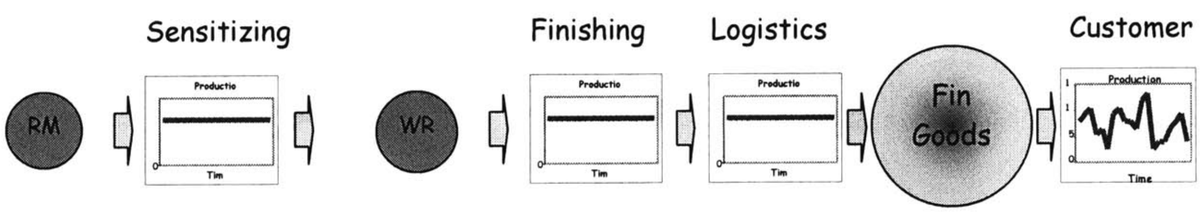


Figure 14 Supply chain with leveling [KOS]

The leveling eliminates fluctuations in demand and allows the upstream processes to plan their resources, and it can eliminate safety stock requirements (seen in the base stock model in Equation 1, STD, the Standard Deviation of Demand goes to zero).

4.2 Heijunka Box

In order to keep the complicated scheduling to takt times and to make the current performance visible, KOS uses a heijunka box to schedule the production. Another function the heijunka box serves as a feedback mechanism. It seems logical that if items are manufactured and sent at the average customer demand, the demand will always be filled. This is not true though. If the items are sent at the average demand and the real demand is stochastic, then the inventory at the destination will fluctuate wildly with excessive shortages or excessive inventory to meet service level requirements. This is due to the accumulated deviation between the actual demand and the average demand. The heijunka box is set up with two limits, which are the "ahead" and the "behind" limits. These limits serve as a signal that something is potentially wrong. Ideally, it would signal that the average customer demand and the takt time are not the same; sometimes it only signals that the accumulated deviation is higher or lower than the set bounds. When one of the limits is hit, the takt time is adjusted to accommodate the signal. Figure 15 shows the Heijunka Box process.

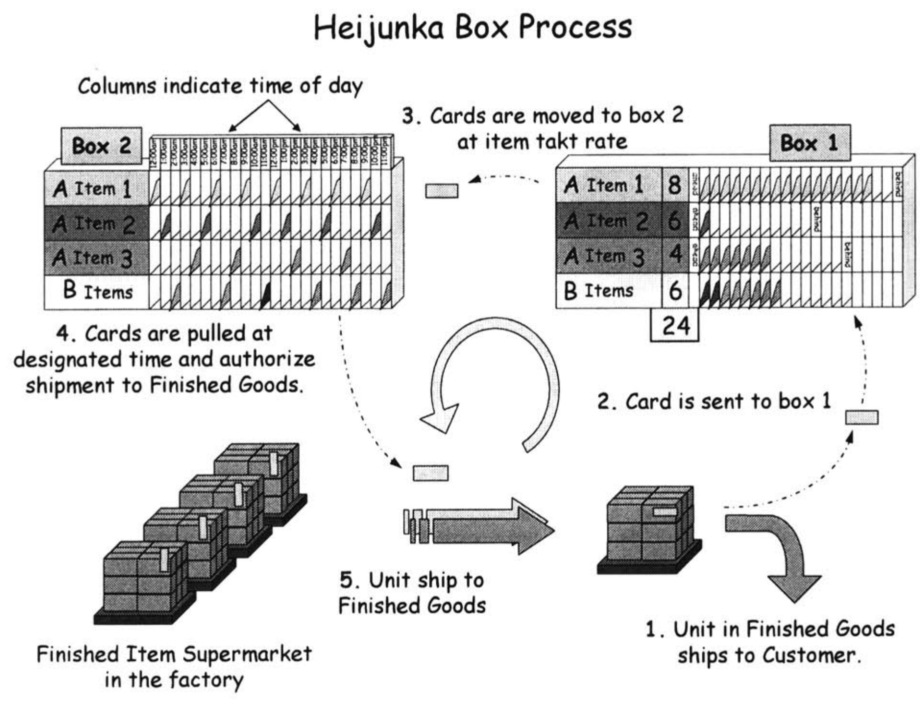


Figure 15 Heijunka box process [KOS]

As finished goods are sent to the customer, the kanban cards are sent to what is called "Box 1." The cards are removed from Box 1 and sent to Box 2 at the takt time. Box 2 is segregated by item and by time of day. At the appropriate time, all items in the same column are pulled and sent to finished goods. When the finished goods are shipped, the kanban card returns to Box 2. Box 2 basically tracks the cumulative deviation between takt time and the realized demand, it has the "ahead" and "behind" limits that signal the need for a change in takt times.

4.3 Benefits of Leveling

The most important benefit of leveling is that the requirements on the available resources are constant. If the demand is highly variable, there are days in which the resources are not utilized and other days in which the demand exceeds the capacity. This makes resource planning difficult. Firms are forced to plan resources for the peaks (or close to the peaks and use overtime). This means that only on the peak days will the resources be adequately utilized, while the majority of the time, the resources will be underutilized. If the demand can be perfectly leveled, the production scheduling can be done in great detail. The entire supply chain can know what has to happen and when. In manufacturing, leveling can help eliminate overproduction, and reduce or eliminate safety stocks, but because logistics only moves materials, the only benefit to logistics is the constant demand on resources.

4.4 Waste at the Source

The purpose of KOS is to eliminate waste in the value chain. One of the ways this is accomplished is by pushing the waste to the source and providing the incentives to eliminate the waste. Leveling does this. Currently, when manufacturing gets an order, they manufacture an entire lot and typically ship the lot (whether to the destination or the distribution center). This creates problems when the order size is much smaller than the batch size (which is practically every case). Manufacturing does not hold finished goods inventory and they cannot see the problems and waste that are caused by batch sizes. In a leveled environment, the product is pulled consistently. This forces manufacturing to have a supermarket of finished goods from which product is pulled. There is now a pile of inventory in manufacturing, it is visible, and they now have the incentive to try to reduce the waste that they cause by reducing batch sizes, setup times, lead times, etc.

4.5 Analysis

The main drivers of cost that are affected by leveling are inventory and labor. Figure 16 shows how the number of containers loaded per day can vary in a month. The average number of containers is actually 9.6 per day.

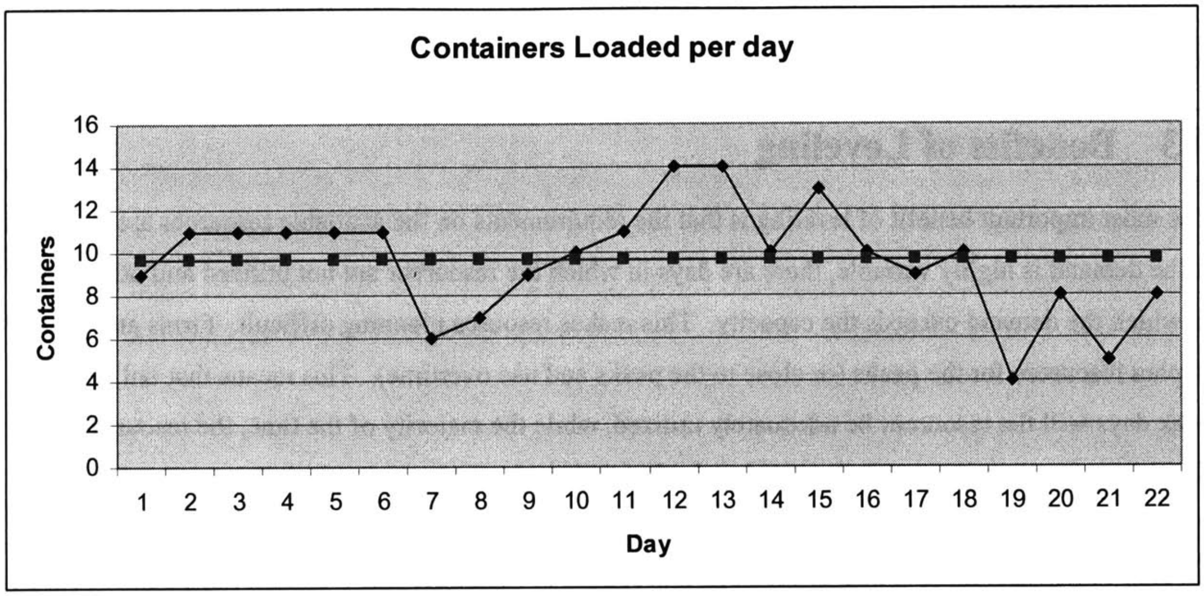


Figure 16 Containers loaded per day in a random month

Kodak must have the staff that can load the maximum 14 containers per day, even though this situation only occurs two times in the month. Kodak has another option, which would be to staff to a capacity of filling 12 or 13 containers, and use overtime to accommodate the peaks. Either way, the staff required for a leveled environment is approximately 70% of what is required to operate in a non-leveled environment. The inventory required to level is normally more than in a system that operates on the base stock model. One of the difficulties of assessing leveling is the fact that each case is different, there is not a mathematical equation that shows the exact increases in inventory. The way Kodak sets up the heijunka box is on a case-by-case basis with some analysis of historical data and some artful alterations to the system. In this case, it will be assumed that the inventory will be increased by 10% (which is in the range of some empirical comparisons). Taking aggregated data, the base stock inventory requirement is approximately 179.7k lb. If the leveled system adds 10%, the additional inventory is 18k lb. At a cost of $5/lb, the total additional cost is $90k. It takes approximately 6 hours on average to load a container. This is due to many transactions that have to take place, as well as stacking and balancing the load within the container. In the sample month, that means that there is a requirement of 84 hours (14*6 = 84). Assuming an 8-hour day, that means that at least 11 employees are required to load the containers. If the system is leveled, the staff only need to load 10 containers per day, which requires 60 hours and that translates into 8 employees. If the cost of labor is $65k/yr, the labor savings for three people is $195k. The net savings is $105k ($195k - $90k = $105k) . There are additional labor savings not mentioned here because the labor spoken of is strictly for loading, but there will also be labor savings from picking the products from the shelf, producing paperwork, and arranging for pickup and delivery of the containers. Again the savings is only what occurs in year 1, the inventory cost is a 1 time cost, but the labor savings is a perpetuity, so the NPV higher than what is presented here. Again, this analysis would need to be done on a lane-by-lane basis because it is hard to generalize the inventory issue since part of the leveling set up is an art where individuals make adjustments that they think are right and not necessarily as a result of rigorous policy. It should also be noted that the true benefits of leveling would only be achieved if all of the work done by logistics were leveled. If there is a mix of leveled work and non-leveled work, then—in total—the work will not be leveled.

4.6 Summary

There are potential benefits in a leveled environment. Leveling allows for minimal resources at high utilizations to accomplish the firm's activities. It allows for a lot of coordination in the supply chain that cannot otherwise be achieved. The benefits derived actually require some detailed analysis to find the benefits of having a constant demand on resources. Leveling actually makes a tradeoff of inventory and other benefits. Empirical calculations hat compare the inventory in a leveled model with a base stock model indicate that more inventory is held in the leveled model. The tradeoff is the leveled demand on all upstream resources and suppliers. A very important consideration for logistics is that the benefits to logistics are strictly the leveled demand on the labor. If logistics consolidates the lanes via cross docking, and manufacturing is able to level its production, then by default, logistics will be leveled. Leveling needs to be taken on by manufacturing and/or production scheduling.
It's also important to note that leveling can be done without consolidating lanes. In Kodak's case, each business unit could level its production and logistics yet still be independent of what other business units are doing. The combination of leveling and consolidation is explored in the following chapters.

Chapter 5 Leveled Cross Dock

5.0 Leveled Cross Dock Operations

This chapter will look at the benefits of leveling a cross dock. The operation is a cross dock because it brings in material from several origins and stages the material according to destination, thus consolidating lanes. It is leveled due to the fact that there is the notion of sending items in a leveled manner according to their takt times. In Chapter 3, it is mentioned that there are two types of cross docks, schedule-driven and load-driven. To review, the distinction is that schedule-driven cross docks send trailers on a certain schedule to ensure service levels, at the risk of sending trailers "light." And load-driven cross docks send trailers when they are full, thus fully utilizing the trailer capacity, but risking the service levels. It seems as though there are also two ways of operating a leveled cross dock, one that is schedule-driven and one that is load-driven.

5.1 Schedule Driven Leveled Cross Dock – Transfreight

Transfreight is the logistics provider for Toyota in North America. Toyota and Transfreight work hand in hand in order to pursue the purposes of TPS and eliminate waste in the system. Transfreight receives the material that is bound for a Toyota plant from various suppliers and sorts the materials by destination. Transfreight also serves as a leveling point in the system, that is, they send the material to Toyota in a leveled manner. Toyota provides its suppliers and Transfreight with a four- week forecast. Transfreight is then able to schedule every detail at one time for the next four weeks. They are able to schedule when supplier shipments will arrive, and they even plan where on the trailer each pallet will go. They do this once every planning period. Toyota may make minor adjustments to the schedule, but for the most part, it is set in stone. If a supplier is far from the cross dock or has to send in large batches due to transportation costs, etc., Transfreight holds the goods on site and sends them to Toyota in a leveled manner along with the other goods that they receive.

5.2 Problems with Schedule Driven Leveled Cross Dock

There are a few problems with the leveled cross dock that operates in a schedule-driven manner. There is no argument that this works great for Toyota, but there are some issues with running a similar facility for Kodak. Due to Toyota's power in the value chain, they are able to do many things that Kodak cannot. When Toyota sets its forecast each four-week period, it knows that the cars that are built will be placed on dealer's lots and sold. The demand for Toyota vehicles is strong. The dealers are the ones that are stuck with the inventory if there is some overproduction. Toyota never has the intent to overproduce, but even if they did, one could argue that the dealers take the brunt of the mistake. There are hints today that Toyota has run into overproduction problems in North America, mostly due to the fact that they are now making some attractive financing offers and rebates on some new vehicles, while their competitors have been doing that for a few years now. Toyota is almost as far downstream in their supply chain as one can get (only the dealers are farther down the supply chain than they). Their position in the supply chain allows them to reap the benefits of leveling and other TPS techniques. The majority of the benefits of leveling are felt by the firms that are upstream in the supply chain. For example, leveling allows elimination of safety stock but only for firms upstream in the supply chain. Kodak is very far upstream in their supply chain. If they level, the benefits are felt by a few firms upstream from them, but the downstream firms can make leveling difficult to implement. The fact that Kodak is upstream and has very little power, relative to their customers, it is hard for Kodak to operate in a leveled manner as Toyota. Any excess that Toyota makes relative to demand sits on a dealer's lot with little threat of return. Any excess that Kodak produces might sit on a retailer's shelf, but the threat of return is very real and costly for Kodak. Another problem with trying to use Toyota's model for Kodak is the fact that Kodak has a huge number of independent products. All of Toyota's products are tied to the same end item. There can be several variations of a car, but in essence, they all have one engine, four wheels, etc. If the takt time changes due to a demand change in cars, the demand for all of the parts gets adjusted by the same ratio. With Kodak, the takt time for one item can change with no effect on the takt time of another item. The takt times can basically be in a state of constant change. For Transfreight, they only have to adjust their detailed plans once every planning period. If Kodak does not hold the volume exactly leveled for all products in a time period, they must change their detailed plan every time the takt time of a single item changes. Execution has to be exact to avoid problems with this type of leveled cross dock.

5.3 Load Driven Leveled Cross Dock

An alternative to the schedule-driven leveled cross dock is one that is load driven. The idea is that all of the goods are brought to the cross dock at their individual takt times. As the goods accumulate, and when the amount of material reaches a set criterion, a trailer is called, and the goods are loaded. The premise here is that the goods come in a leveled manner, and they flow through the cross dock in a First In, First Out (FIFO) manner, and they should leave in a leveled manner and arrive at their destination in a leveled manner. This would still be different from a schedule-driven cross dock in the sense that the trailers only go out when they are full, which is a function of the takt times of all the materials that flow into the facility. The trailers are not all scheduled and planned to perform exactly the same each time. If some material has a problem, the entire shipment will not be held up; whatever is next in line will be loaded and shipped. This can be done because the products are quite independent. In the Transfreight example, if the tires have problems, then the whole shipment of items that generally get put onto the same car as the tires must be held up because Toyota cannot build the car without the tires. In Kodak's case, if one item, such as film base, does not show up, Kodak could still make paper and other items that do not depend on the film base. That being said, it is important to note that some of the goods are dependent. There are chemicals that must arrive with other goods to make things such as film, etc., but the interdependency is not as great as in the Toyota examples. A load driven cross dock is more forgiving of execution errors since the whole system doesn't stop if one product is not in the right place at the right time.

5.4 Summary and Conclusion

Leveled cross docks are a combination of leveling and lane consolidation through cross docking. There are several benefits that are achieved through this combination. Potentially, lane consolidation benefits as well as leveling benefits are gained. The decision as to which way to operate the cross dock needs to be considered carefully. There are tradeoffs of service and transportation costs that need to be taken into account, but interdependence of products may also play a role in the decision. The amount of communication that needs to take place as well as execution ability may affect whether to run the leveled cross dock in a schedule driven or load driven manner.

Chapter 6 Proposed West Coast Cross Dock

6.0 West Coast Cross Dock

The West Coast cross dock has been proposed as a potential improvement for the global logistics network. The intent of the project is to consolidate all domestic products bound for export to Xiamen (China), Shanghai (China), Hong Kong (China), Japan, South Korea, Singapore, and Australia. This would mean that each destination would be receiving containers from the same domestic location. Figure 17 shows what this network would look like (Graphic taken from http://www.eduplace.com/ss/maps/pdf/world_pacific.pdf).

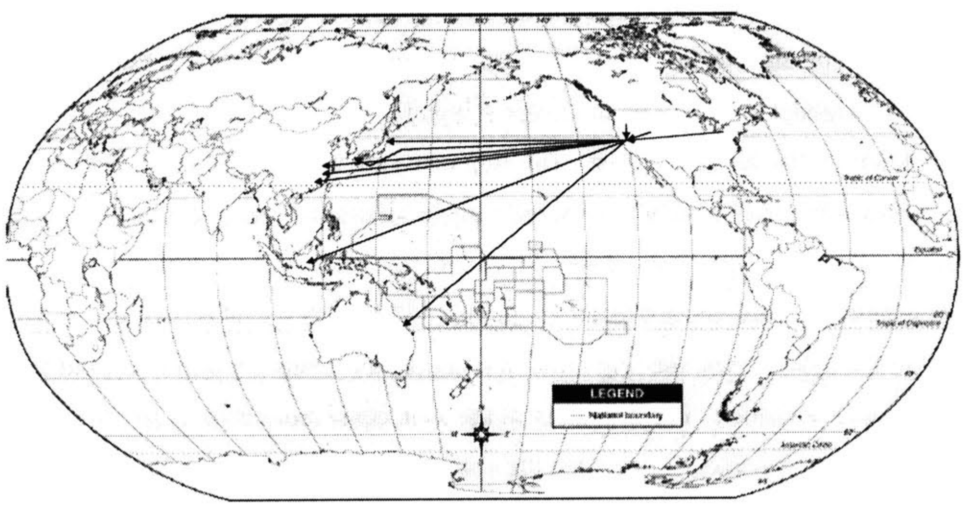


Figure 17 Export network using a west coast cross dock

All of the domestic sites will send the export material to another domestic site. This site (presumably on the West Coast somewhere for easy access to the ports) will act as a cross dock by co-loading material from the three domestic sites in Rochester (New York), White City (Oregon), and Windsor (Colorado) and staging it into lanes according to the destinations. The West Coast cross dock will also level the materials according to the takt times determined at the destinations. The project also assumes that leveled cross docks will also be run at each of the domestic sites to consolidate everything from each origin.

6.1 Questions About West Coast Cross Dock

There were many questions about the West Coast cross dock. It was not clear how large the facility had to be, Kodak has some extra room in an existing facility, but would it be sufficient or would they need to buy or lease additional buildings? The manpower requirements were not clear nor was the amount of inventory that would accumulate as a result of the mismatches in timing of arrivals and departures, as well as the accumulations that might occur due to the leveling of the materials.

6.2 Simulation Model

In order to figure out the questions with regard to inventory, manpower, and space requirements, a discrete event simulation model was created using ProModel software. A simulation was used because of the interdependencies of the many variables and the stochastic nature of the problem [Harrell, 2000]. The model uses data on materials shipped between the origins and the destinations; it then levels the loads out to the West Coast. The shipments are unloaded at the facility and staged according to destinations, and the loads are leveled again by destination. Containers are loaded as the staging lanes are filled and taken to the dock. Ships are scheduled on a weekly shipping frequency and they load whatever containers are ready at the time. The loads are taken to the destination and unloaded. All of the move times, loading times, and unloading times are estimated, but they are modeled as stochastic variables. The inventory at the west coast cross dock is an observed output and the staffing levels can be adjusted to see what the optimum levels are with tradeoffs of inventory accumulation and utilization.

6.3 Data

The required data is as follows:

- Amount of material over some recent time period that was sent from the origins to the destinations
- Travel time distributions from each origin to the west coast and from the west coast to the destinations
- Load time distributions - time required to load a container/trailer
- Unload time distributions – time required to unload a container/trailer

Kodak uses a database called the Global Data Warehouse (GDW). A lot of data concerning products shipped from the origins to the destinations was pulled from the 2nd quarter of 2004. This data was manipulated in an Excel spreadsheet in order to make it useful. Data integrity was a concern. Much of the data accuracy depends on "Master Data Tables" that are in the reporting system. One example is weight per unit. If the system indicates that 10 items were shipped, then a master data table for the weight per item is referenced to give the weight of the shipped goods. The master data tables are entered manually and need to be updated when something changes such as the number of units per pallet. The manual data entry and lack of a system to maintain current information makes it difficult to entirely trust the data. Where possible, the information was screened for reasonableness by experienced people and the data was referenced to information from other sources as a further screen of accuracy.

6.4 Network and Processes

A network was drawn up similar to that shown in Figure 18 with all of the daily volumes of material that flow throughout the network. For example: Windsor exports 27% of the daily export volume and Australia receives 12% of the daily export volume.

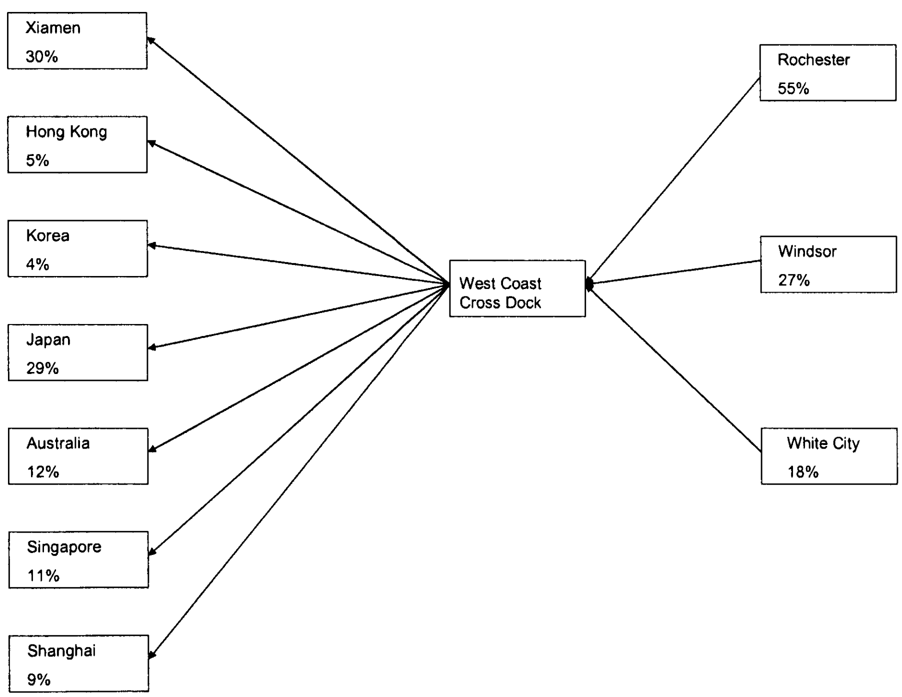


Figure 18 Export network with percentage of daily volumes

A further breakdown of the export materials was done to see how much of the daily volume from each origin went to each destination. Figure 19 shows the information for the origins and the distribution of daily volumes to the destinations. For example, 24% of the material that is sent from Rochester is bound for Japan.

Source	Destination	% from KP to destination
Rochester	Australia	14.63%
	Hong Kong	7.14%
	Japan	24.17%
	Korea	7.35%
	Singapore	9.62%
	Xiamen	35.75%
	Shanghai	1.34%
Rochester Total		**100.00%**
		% from WC to destination
White City	Japan	63.15%
	Xiamen	0.20%
	Shanghai	36.65%
White City Total		**100.00%**
		% from Windsor to Destination
Windsor	Australia	14.11%
	Hong Kong	2.89%
	Japan	16.01%
	Korea	0.26%
	Singapore	21.54%
	Xiamen	39.41%
	Shanghai	5.78%
Windsor Total		**100.00%**

Figure 19 Distribution of materials to destinations

Figure 20 shows the same information from the perspective of the destinations: it shows how the daily volume of export material is divided among the origins. For example, 68% of the material that arrives in Australia is from Rochester.

Destination	Source	% from origin to Australia
Australia	Rochester	68.07%
	Windsor	31.93%
Australia Total		**100.00%**
		% from origin to Hong Kong
Hong Kong	Rochester	83.56%
	Windsor	16.44%
Hong Kong Total		**100.00%**
		% from origin to Japan
Japan	Rochester	46.15%
	White City	38.98%
	Windsor	14.87%
Japan Total		**100.00%**
		% from origin to Korea
Korea	Rochester	98.28%
	Windsor	1.72%
Korea Total		**100.00%**
		% from origin to Singapore
Singapore	Rochester	47.87%
	Windsor	52.13%
Singapore Total		**100.00%**
		% from origin to Xiamen
Xiamen	Rochester	65.02%
	White City	0.12%
	Windsor	34.86%
Xiamen Total		**100.00%**
		% from origin to Shanghai
Shanghai	Rochester	8.38%
	White City	74.05%
	Windsor	17.57%
Shanghai Total		**100.00%**

Figure 20 Distribution of export materials from destinations

These two breakdowns are useful in figuring out the configurations of the trailers and containers in the network. In a leveled environment, each trailer that leaves White City for the West Coast cross dock will be filled with the percentage of material outlined in Figure 19. For example, if the trailer is filled to capacity (45,000 lb) then 28,417.5 lb (63.15% * 45,000 lb) are bound for Japan, 90 lb (.2% *45,000 lb) are bound for Xiamen, and 16,492.5 lb (36.65% * 45,000 lb) are bound for Shanghai. Similar calculations can be done for the container configurations using the information in Figure 20. For example, if a container is filled to capacity (40,000 lb), then each container sent from the West Coast cross dock to Singapore would have 19,148 lb (47.87% * 40,000 lb) of material that comes from Rochester and 20,852 lb (52.13% * 40,000 lb) of material from Windsor. There are several assumptions in this layout of the model. First of all, it assumes that the material can break down into the exact weights derived from the data. The Excel spreadsheet was also used to calculate takt times for the trucks that leave the origins. This is not how a real leveled system would operate in the sense that the trucks do not have takt times; the rate at which the trucks depart is a function of the takt times of the materials that go onto the trucks. But, again, in this model, it is assumed that the origins are sending the materials at the exact takt times and the rates are not changing over some time period. The trucks have to travel for some time to get to the West Coast cross dock. The stochastic nature of the times is captured in the model. When the trucks arrive at the West Coast cross dock, workers are used to unload the trucks and sort the materials into staging lanes. Once enough material has accumulated for a container to be filled, a container is sent to the cross dock and filled—again using a worker. When the container is filled, it is sent to the ort and waits for the ship. Ships arrive once a week and every time a ship arrives at the port, whatever containers have accumulated at the port are loaded onto the ship and it leaves for its destination. The model does a little more than this, but any discussion as to the model processes past this point are irrelevant to the discussion and the questions that needed answers.

6.5 Staffing Levels

The unloading of the trailers and the loading of the containers are stochastic in nature and the model accounts for this fact. The system is constrained by the number of workers at the cross dock. The workers are resources without which, nothing can happen. The workers can also only do one task at a time, i.e., they cannot load a container and unload a trailer at the same time. So, the loading and unloading functions can only take place when there are free resources. If there are too few workers, then there are not enough resources to do the work, and the cross dock becomes an infinite queue. If there are too many workers, they have a lot of idle time and the labor costs are not justified. There is a balance that needs to be achieved between inventory and worker utilization. Figure 21 shows the growing inventory levels if there is only one employee is used per shift.

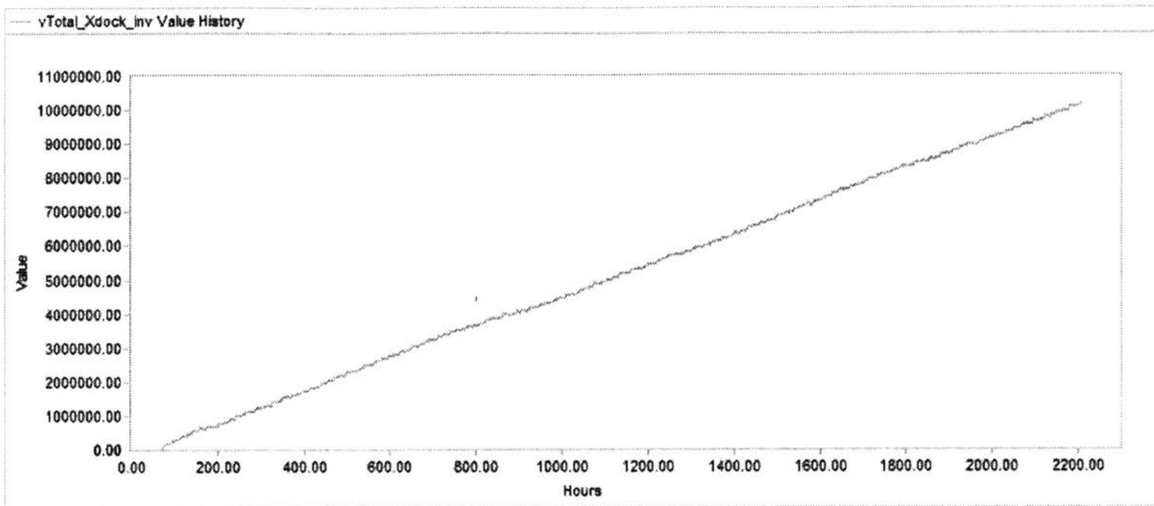


Figure 21 Inventory at the west coast cross dock with 1 employee per shift

Figure 22 shows the inventory at the West Coast cross dock with six employees per shift. In both Figure 21 and Figure 22, the inventory starts off at zero and quickly builds. This is due to the fact that the facility starts out with no inventory in it.

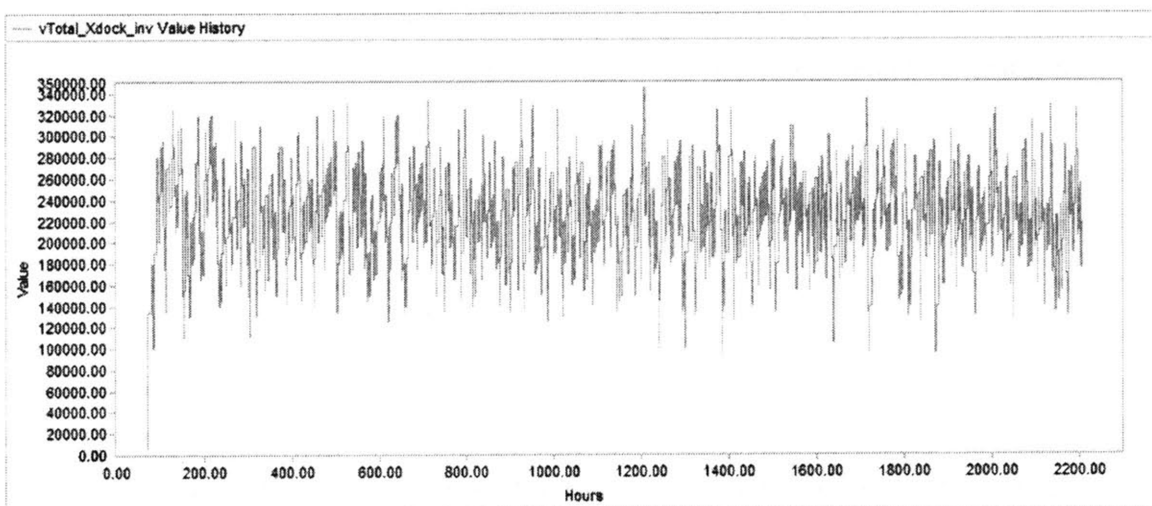


Figure 22 Inventory at the west coast cross dock with 6 employees per shift

Figure 22 shows that the inventory levels fluctuate somewhat but seem to be consistent, meaning that it is not constantly growing over time. The results for the scenarios using one to six employees are outlined in Table 2.

Number of employees per shift	Average Utilization	Average Inventory (lbs)	Avg inventory (days demand)
1	100%	NA - infinite growth	infinite
2	81%	247,845	0.87
3	54%	227,322	0.80
4	41%	222,416	0.78
5	32%	220,682	0.78
6	27%	220,017	0.77

Table 2 Simulation results

Table 2 shows the utilizations of the employees, the average inventory held at the facility in both pounds and in terms of day's worth of demand. The natural argument against three employees per shift would be that, apparently, they are doing nothing for 46% of the time. While this may seem like a valid point, there are a couple of reasons why three employees per shift would be appropriate. First of all, with no other changes, as utilization increases, cycle time increases in an exponential manner (potentially infinite) [Hopp, 1996]. Second, during the "down" times, they can be doing other work that was not accounted for in the model, and depending on execution, could be significant. The main component of this work is communication between the origins, destinations, the port, the trucking companies, etc. It should also be noted that the facility under consideration is also a regional distribution center for Kodak, so if major downtime occurred, the "extra" employees could supplement work in the distribution center.

6.6 Space Requirements

The amount of inventory is a function of many variables, such as the amount of incoming and outgoing material, arrival rates, manpower, mismatches in loads, as well as the effects of the leveling at both the origins and the cross docks. In order to figure out how much space is required, the trailer configurations were compared to the container configurations. A ratio was taken of the amount of material that comes in on each trailer and is bound for a destination, relative to the amount of material bound for each destination from each origin. If a trailer arrives and contains more than one container load for a certain destination, then more than one staging lane will be required. For example, Table 3 shows the configuration of containers that are bound for Shanghai. If the container is filled to capacity, then 3,352 lb on the container will be from Rochester; 7,027 lb will be from Windsor; and 29,621 lb will be from White City. Again, this is known because the loads are assumed to be perfectly leveled for the destinations, so every container going to the same location will look the same.

Destination	Origin	Weight (lbs)
Shanghai	Rochester	3,352
	Windsor	7,027
	White City	29,621
	Total	40,000

Table 3 Configuration of containers bound for Shanghai

Table 4 shows how many pounds are on each trailer from the origins that are bound for Shanghai. For example, each trailer that leaves Rochester has 603 pounds that are headed for Shanghai.

Trailer origin	Lbs per Trailer bound for Shanghai
Rochester	603
Windsor	2,599
White City	16,492

Table 4 Lbs per trailer from the origins bound for Shanghai

The ratio of amount of material that comes in on each truck for a destination relative to the amount of material required for each container determines how many lanes are required, an example is shown in Table 5.

Rochester	0.18
Windsor	0.37
White City	0.56

Table 5 Ratio that determines number of staging lanes required

For example, each trailer from Rochester has 603 lb on it that are bound for Shanghai, and each container requires 3,352 lb from Rochester, so 1 staging lane (603/3,352 = .18) is required for the Shanghai lane. The highest ratio for each destination is taken to decide the number of staging lanes (Note: Windsor and White City also only require 1 staging lane in this example). In reality, even though the analysis might indicate only one staging lane is required for a certain lane; at least two will be necessary. This is due to the fact that material will arrive while a staging lane is being loaded into a container. Using this process, the data indicates that 16 staging lanes are required at the West Coast cross dock.

Assuming that the decision is made to have three employees run the cross dock, the maximum amount of inventory in the facility is 370,000 lb or 1.3 day's worth of inventory. This translates into 9.25 staging lanes worth of material (370,000 lb/40,000 lb capacity). This maximum is much less than the 16 lanes indicated in the previous analysis, which is a good check. Even though there might be 16 lanes, they are all at various stages of being filled, some might be completely full and waiting to be loaded, and others might be empty, while the rest are partially full.

6.7 Lead Time

In the current process, containers that leave Rochester headed for the seven destinations first go to New Jersey by truck. The containers are then either loaded onto ships to go the long way around the world to their destinations or they are loaded onto trains to go to the west coat by rail. The trip from Rochester to the West Coast ports takes about 13 days. Even if the containers are shipped from the east coast, they take approximately 13 more days to go from the U.S. port to the destination port. With a West Coast cross dock, the material will be shipped by truck to the West Coast which takes approximately three days. The new process takes 10 days' lead time out of the network on a majority of the products headed to the West Coast for export, thus reducing the inventory in the system.

6.8 Analysis

If the West Coast cross dock is compared to the current state, it looks like a promising project that will save money. If the marginal benefits are analyzed, the story is not necessarily the same. The first major assumption for the West Coast cross dock was that the incoming materials come from other leveled cross docks. The benefits of leveling already exist from the cross docks that feed the West Coast cross dock. As far as inventory is concerned, the leveling at this second cross dock actually causes an increase in inventory due to the mismatches in timing and load sizes. If there are 3 employees per shift, and an average of 227,322 lb of inventory is located at the facility (from Table 2). At $5/lb, this is an additional cost of $1.13M. There is a reduction of lead time from Rochester of 10 days, and at approximately 157k lb per day leaving Rochester, the reduction of inventory is 1.57M (157k lb*10=1.57M lb) pounds. At a cost of $5 per pound, the savings is $7.85M. Also, due to the further consolidation of lanes, the number of lanes is reduced from 21 (3*7 = 21) to 10 (one from each of the origins to the West Coast cross dock and then one to each of the destinations). The inventory savings from this would be another 440k lb of inventory (11*40k lb=440k lb). Again, at a cost of $5/lb, the savings is $2.2M. With inventory, the net savings is $8.92M. Labor will increase by nine people, if the cost per person is $65k, the new cost of labor goes up by $585k. In order to run the West Coast cross dock, the IT system requires an upgrade at a cost of approximately $300k. The transportation costs are also different. Without the West Coast cross dock, the containers are sent by rail from Rochester; but with the West Coast cross dock, the material is trucked to the West Coast. Also, White City now has to travel a bit farther and use a different port than they normally would. In general, the cost per pound is more for White City and Rochester to ship through the cross dock than direct from the origins. The annual difference is about $620k more per year. The first-year cost difference is a savings of $7.41M. The year 1 results are summarized in Table 6.

	Savings	Costs	Net
Lead Time Inventory Reduction	$7,855,000	$0	$7,855,000
Lane Consolidation	$2,200,000	$0	$2,200,000
IT Investment	$0	$300,000	($300,000)
Inventory at West Coast Cross Dock	$0	$1,136,610	($1,136,610)
Added Labor	$0	$585,000	($585,000)
Additional Transportation	$0	$620,000	($620,000)
Total	$10,055,000	$2,641,610	$7,413,390

Table 6 Summary of year 1 results

Over a 10-year period, assuming a 5% growth in labor and transportation costs, the project is a marginally positive NPV project if a discount rate of 13% is used. The biggest driver in this case is the weighted average cost of the inventory, which was assumed to be $5/lb, but at higher values, the project looks more promising. One issue is that the inventory benefit is a one-time benefit, but the labor cost and the additional transportation costs are effective year over year. This is different than most projects which have an upfront capital cost and the benefits come in over the next few years. In normal situations, if the time period is longer, the NPV goes up, and if the discount rate is lower, the NPV goes up. In this case, if the time period is longer, the NPV goes down, and if the discount rate goes down, the NPV also goes down because the future costs are discounted less. If the time frame is adjusted to a 5 year period, the NPV is higher. There are many assumptions in this analysis that may be different at Kodak. If the IT investment has already been spent or is used for other projects, then it can change the NPV. The discount rate is probably different, and since the volumes are expected to decrease over time, then the costs will likely also decrease over time making the project more attractive. Other issues that may change the analysis are: the use of contract labor instead of Kodak direct labor, indirect labor benefits that aren't quantified, and the concept of inventory holding costs that will also affect the analysis. Table 7 shows the sensitivity of the NPV due to the discount rate and value of the inventory using the same assumptions as before. At a discount rate of 13% and an inventory cost of $5/lb, the NPV is $129k.

	Inventory Cost ($/lb)			
Discount Rate	$5	$10	$15	$20
10%	($830,868)	$8,087,522	$17,005,912	$25,924,302
13%	$129,370	$9,047,760	$17,966,150	$26,884,540
15%	$677,251	$9,595,641	$18,514,031	$27,432,421
17%	$1,163,448	$10,081,838	$19,000,228	$27,918,618

Table 7 Sensitive analysis of NPV

What the analysis doesn't include is other risks, such as execution risk and the risk or cost of additional communication and organizational burden. The west coast cross dock is a new concept for the company, so even though the numbers can look promising, there are other risks to take into account. The west coast cross dock will require a lot of communication that includes a third party that neither makes the goods, or consumes the goods, but is critical to the overall supply chain effectiveness.

6.9 Conclusion

The proposed West Coast cross dock is a fairly complex operation in which the KOS principle of leveling would be implemented. A simulation was created to evaluate the staffing and space requirements. Inventory will be accumulated at the facility due to the mismatches in timing and load sizes of the inbound and outbound materials. Looking at the marginal benefits of the project shows that, under certain assumptions, it is a marginally positive NPV project. In this case, leveling is actually a detriment to the project because it causes an increase in inventory that has to be held at the facility.

Chapter 7 Recommendations

7.0 Recommendations

The first chapters of this thesis explore Kodak's current state along with the challenges that the firm faces. The topics of cross docking, leveling, and the combination of the two are also discussed. Based on the principles that are discussed, there are several recommendations that are prudent for Kodak. They are as follows:

A. Run localized cross docks
B. Add inventory to accommodate full container shipments
C. Stabilize the system and evaluate inventories and variation
D. Level shipments
E. Monitor and improve
F. Refine analysis of West Coast Cross Dock

These recommendations are specific to Kodak. Drivers that may change the recommendations for other situations are the inventory costs, transportation costs, and labor costs. As inventory costs go up, then adding inventory to the system may be more costly than sending

7.1 Run Localized Cross Docks

Chapter 3 discusses the many advantage of running cross docks. If the cross docks are localized so that everything leaving an area (i.e., Kodak Park) leaves from the same location, there are many benefits. The major change that needs to take place is that Kodak Rochester Transportation? (KRT) would need to make frequent "milk runs" to pick up orders from the various buildings and bring them to the cross dock. This might cause some resistance on the part of the KRT staff, but their incentives need to be reevaluated and probably changed, in order for them to appropriately support the project.

7.2 Add Inventory to Accommodate Full Utilization

This suggestion is mentioned in Chapter 3. Inventory can be added to the system to optimize transportation costs. The reason that transportation costs should be optimized is that the relative value of the goods being exported is low due to transfer pricing and the fact that the distance is so long. It would be a different story if the goods were very valuable or the distance was shorter. If the goods were very valuable, it would probably be worth shipping by air in order to reduce lead time and reduce the inventory requirements. Kodak can use inventory to get the benefit of optimized transportation costs. The cross dock could have an operating rule that dictates that once a staging lane reaches 40,000 lb, it would be loaded and shipped, instead of the current rule that dictates 9,000 lb. This would also make operations easier by reducing the number of decisions and communication that needs to take place. There might be some lanes that typically cube out before they weight out, and the cutoff can be adjusted to accommodate this fact. But it is important to set the goal as high as possible and to back off from it, rather than to start low and build up.

7.3 Stabilize the System and Evaluate Inventories and Variation

Once the system is setup and running, there will probably be a lot of firefighting that is necessary with any large changes. Once the system is somewhat stabilized, it should be evaluated. The inventory situation should be looked, at as well as variation in shipments. Past data can be analyzed to see if it would be better to change the operating policy of the cross docks in order to reduce total cost. The safety stock, due to operating policy, can be eliminated, but the transportation costs would go up because several containers would be shipped in less than full quantities. The variation of shipments should also be analyzed. This is related to the next section about leveling. The only real benefit that logistics gets from leveling is the constant demand on the resources. One of the employees in the Kodak-to-Kodak area mentioned that 67% of the activity happens on Thursdays and this is due to the deadline for making the getting product to the ships to adhere to the shipping frequency. Shipping data from an independent source was acquired and analyzed. Table 8 shows the relative number of shipments by day of the week for two months taken at random in 2004.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Month 1	15.4%	17.4%	24.1%	28.2%	13.3%	0.0%	1.5%
Month 2	19.2%	21.0%	21.9%	19.2%	15.5%	1.8%	1.4%

Table 8 Shipments by day of the week for 2 random months in 2004

Table 9 shows the relative volume (weight) shipped by day of the week for 2 months taken at random in 2004.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Month 1	15.40%	18.46%	24.71%	26.49%	13.03%	0.00%	1.91%
Month 2	18.58%	20.83%	23.04%	19.37%	15.59%	1.45%	1.14%

Table 9 Volume shipped by day of the week for 2 random months in 2004

The data shows that there is some variation in the shipments, but not the 67% that was reported. Figure 16 showed the variation that there is in the system with the shipping frequency being taken into account. With the new policy of shipping the container when it is full, one would expect the variation to go down further. The orders cannot be planned to come in just before the ship leaves port. If the variation is low, the option of leveling might not have any benefit to the logistics organization.

7.4 Level Shipments

This is actually a contingent suggestion. If the variation is somehow high for shipments, etc., the shipments might need to be leveled. The shipments are a function of the materials that are ordered or made by manufacturing. Logistics is responsible for moving product from one place to another, other groups control the quantity and timing of the material requirements; so if production control levels the load, it should translate into a level demand for manufacturing. And if logistics operates in an FIFO basis, they will have level shipments. Some complicating factors to leveling are Kodak's value chain power, or the lack thereof, and the highly promoted products that Kodak produces. Empirical evidence shows that leveling adds inventory to the system when compared to the base stock model. This step is taken to gain other advantages. The leveled loads allow an elimination of safety stocks upstream, and theoretically, the manpower can be reduced because the staffing now has to accommodate a leveled demand instead of staffing for the peaks in demand. In reality, leveling should be driven by manufacturing or production control [Liker, 2004]. The reality is that with the large lot sizes and the high capital equipment costs in an industry that is declining, it is tough to justify the costs of equipment to create smaller lot sizes to accommodate leveling. Even Toyota executives understand the difficulty in some of the things that they do. In 2002, Fuji Cho, President of Toyota Motor Corporation said, "There are many things that one doesn't understand and therefore we ask them why don't you just go ahead and take action; try to do something?" [Liker, 2004]. Since Kodak has adopted KOS as its operating philosophy, it seems as though some steps should be taken on faith. It seems as though the message is "you don't understand, but when you do it, you will then understand." It is hard to make a recommendation on this type of subject, unless one has been through it and can testify to the value of such action. Mr. Cho also says that leveling is the foundation of the other techniques and that if production is not leveled, then the other techniques are useless [Liker, 2004]. A response in this context is that logistics can do some things to try to reduce the variation; and once it is fairly stable, it can implement other techniques, but the real drivers of leveling are in manufacturing or production control.

7.5 Monitor and Improve

This is the theme of any TPS-related process. One must understand that the lean journey is just that, it is a journey, and it really has no end. Womack and Jones term this phase as perfection [1996]. They mention that one should have a picture of perfection and understand that this picture is imperfect and needs to be improved constantly, in fact they state, "Trying to envision it (and to get there) is actually impossible, but the effort to do so provides inspiration and direction essential to make progress along the path." [Womack, 1996]

7.6 Refine Analysis of West Coast Cross Dock

When the West Coast cross dock was evaluated, it appeared to be a very promising proposition. Once the benefits of cross docking and leveling were evaluated separately and the marginal benefits and marginal costs of the West Coast cross dock were looked at, it was not as appealing. A huge part of the benefit comes from the local cross docking activities that were assumed in the analysis of the west coast cross dock. Other factors that can affect the analysis are the volume declines and plant closings, which occurred after this analysis was done, and future expected closings. The future plans of the affected areas need to be taken into account, for example, if the semi-finished goods will soon all be made in places other than the U.S, then the time frame for the project is extremely important. The key factor is the cost of the inventory. This cost is the biggest driver, so its accuracy is critical. Further analysis should be done to compare the tradeoffs of the IT investment, inventory, and labor costs (including indirect labor cost benefits). The time period for the analysis, inventory costs, and assumptions about how fast the volume will decline contribute to make the project look favorable or not favorable. This potential benefit has to be weighed against other risks that are difficult to quantify such as execution risk and the effects of added communication and complexity.

7.7 Lessons Learned

The key takeaway from this effort is that it's important to understand what changes cause which benefits. When the west coast cross dock was originally analyzed, it was very favorable. The problem was that a lot of the benefits actually derived from the assumptions made about the localized cross docks that were to feed the west coast cross dock. As the marginal benefits of the west coast cross dock were analyzed, it becomes a little more unclear as to whether or not it is a good idea. The final decision will depend on the true value of the inventory and the time frame for the financial analysis. Another key takeaway is that there are many risks and benefits that can't be quantified such as indirect labor savings, cost of complexity savings, execution risk, etc. Even with a financial analysis that shows a project worth doing, managers have to be subjective in how these other factors affect the project and it would be perfectly rational for a manager to *not* go forward with a positive NPV project if the other risks are very large in their estimation.

Another key lesson is that data is the only true objective indicator of performance. All humans are biased to certain ideas or may take actions according to what they believe. By using data to back up decisions, this bias is removed and can be a powerful tool in overcoming bias. This bias can be innocent, for example, when asking about carrier performance, people seem to relate the overall performance as the worst one-time incident that they can remember. This conservatism can cause problems without real data to back it up.

7.8 Conclusion

With the constant pressure to decrease costs, outsourcing is becoming more popular, especially to areas with very low labor costs, such as Asia. This trend is making it so that logistics is becoming a much larger part of the cost of goods due to the distance traveled. The global nature of some businesses also requires long supply chains, but the message is the same—that with long supply chains, logistics matter more. The logistics systems can affect the supply chain and operations in many ways. Inventory policies and operations can be altered due to logistical needs. Complications in the logistics network have created new sets of problems that have not, in the past, been as important to firms. In TPS (or KOS), there is a certain element of just doing and following. A lot of the analysis has been done at a fairly high level due to limited data. More analysis on cross docking is probably unnecessary due to the very large benefits of cross docking. More analysis is suggested on leveling because the benefits come from many areas in which data simply was not available. This analysis should be taken to manufacturing or production control because most of the benefits are derived upstream of the leveled points. Many decisions involve trade offs that need to be made among various factors in business decisions, but understanding the tradeoffs can make the system as a whole better.

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