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The Reengineering of a Computer Assembly Plant

by

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Submitted to the Departments of Mechanical Engineering and
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Abstract

Over the past five years, the Salem, New Hampshire facility of Digital Equipment Corporation ("Digital") has undergone drastic changes in its layout and in the products it assembles. The rapid closings of three North American plants and their subsequent consolidation into the Salem facility were implemented, on average, over a period of only three months for each plant closing. As the new businesses were added, Salem management had neither the time to consider the strategic and operational impacts of changing the functions performed at Salem, nor the luxury to redesign the facility to optimize material flows.

In the Spring of 1997, the Salem facility began a series of major reengineering initiatives whose objective was to correct layout inefficiencies and optimize the functionality of the facility to meet world class manufacturing standards. The goal to develop the facility into a contiguous and integrated manufacturing organization was driven largely by increasingly strong competition.

The work performed for this thesis consisted of two major tasks: first, to undertake a strategic and operational analysis to identify a superior factory layout given the addition of new functional capabilities at the Salem facility; and second, to design a financial model to assess the operational impacts of the proposed and on-going reengineering efforts. Both tasks involved a team-based approach with Digital employees.

Five key recommendations and conclusions were made as a result of the analyses:

- Placing the order consolidation, shipping, and options fulfillment businesses in Core B of the factory will allow for a superior flow of material through the Salem facility.
- Bringing the order consolidation, shipping, and options fulfillment functions into the Salem facility will allow the factory to improve order delivery predictability and reduce total order cycle time.
- By becoming more vertically integrated, the Salem facility has a much higher probability of achieving its performance goals for FY'98.
- Accounting for opportunity costs not captured in other potential reengineering plans, the proposed reengineering plan offers both a high return from direct program savings as well as the potential for manufacturing capacity expansion.
- Accounting for the non-quantifiable benefits of the proposed reengineering program will show that the long-term strategic rewards for Digital far outweigh any of the short-term savings.

The remainder of this document describes the two tasks completed in greater detail, explains the methodologies used in assessing the potential financial and operational impacts of the factory changes, and justifies quantitatively the recommendations made above.

Thesis supervisors: Lawrence Wein, Professor of Management Science
Alvin Drake, Professor of Systems Science and Engineering

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For Margaret

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Chapter 1 - Introduction

Problem Statement

The Salem, New Hampshire facility is one of six Digital factories currently in operation. Under a mandate to make the Salem facility capable of meeting world-class manufacturing standards, management has undertaken several key reengineering initiatives to reach this objective. As a result of these initiatives, there exists a need to redesign the factory and improve material flows within the factory. Furthermore, the overall strategic and financial impacts of all reengineering efforts on a factory-wide basis (versus a project-specific basis) have not been evaluated. Thus, this thesis answers two specific questions:

- *What is a superior factory layout given the addition of new functional capabilities?*
- *What are the total potential financial and operational benefits of the reengineering initiatives at the Salem facility?*

Approach and Methodology

A comprehensive approach was undertaken to complete the two tasks outlined in the Problem Statement. First, relevant data was collected to assist the team in understanding the factory environment and current issues. Each team was led by this author and consisted of two or three other individuals from the Salem facility. Teams were formed to evaluate factory layout and capacity issues, as well as financial impacts of the proposed changes. Second, on-site interviews were conducted with key personnel to collect more specific data and other necessary information. Third, models were developed to quantify costs and benefits of the proposed layout. Finally, throughout the six-month internship, weekly meetings were held with an eight-person Steering Committee, consisting of senior management from the Salem facility, to gain additional direction on the "to be" scenario (i.e., future vision of the factory) and feedback on the analyses being conducted.

The specific approach and methodologies used to complete the operational and financial analyses were as follows:

- *Strategic analysis of functional capability.* From interviews with Steering Committee members and a high-level process mapping of material flows (supplier, factory, distribution center, customer), a strategic analysis of the "as is" and "to be" functions at the factory was completed.

- *Factory layout analysis*. The initial analysis involved a "greenfield" approach. That is, assuming the existence of an empty factory (or a "greenfield") and an opportunity to completely redesign the factory layout given the "to be" functional capabilities, what would the factory look like? Five potential scenarios were developed by the factory layout team and presented to the Steering Committee for review. The Committee selected the most promising factory layout based upon initial estimates of the time to implement, cost to implement, disruption due to implementation, and anticipated benefits of the new layout once the implementation was complete. Subsequently, a material flow analysis was performed using the recommended layout. The objective was to determine whether the selected factory layout minimized material flow as much as possible, thereby simplifying the flows and reducing the amount of material handling required. As a result, a realistic and achievable factory layout was developed to improve and simplify the flow of material across the floor.
- *Factory capacity analysis*. Using historical data on material receipts and planned capacity for the factory's production, two spreadsheet models (for input and output) were created to make recommendations on the number of dock doors required in the warehouse for receiving and in Core B for shipping. Because of the analyses completed above (functional capability and factory layout), there was a need to understand how the proposed changes would impact the flow of material into and out of the facility.
- *Financial impact analysis*. In conjunction with the Finance Department, a net financial impact analysis was performed using a spreadsheet model. Five iterations of the selected layout were developed to account for potential changes in timing and capital availability and include the costs and benefits of the other reengineering efforts occurring simultaneously.

As a result of these analyses, a Capital Appropriations Request (CAR) was developed to summarize the work performed. The CAR was presented to Digital Corporate in November 1997 to justify the capital that was required to make the proposed changes. $3.4 million was subsequently approved based on these analyses.

Background

Digital Equipment Corporation ("Digital") is a leading worldwide supplier of networked computer systems, software, and services. Half of its revenues are derived from outside the United States, developing and manufacturing products and providing customer services in Europe and Asia. As of December, 1997, Digital employed approximately 55,000 people worldwide with revenues in excess of $14 billion annually.

The Salem, New Hampshire facility is Digital's largest workstation and server assembly plant. The plant is responsible for over $4 billion in annual revenue, both from sales of products manufactured on-site and services provided at the factory. Depending on seasonal demand for its products, the Salem plant employs between 1100 and 1600 people. Approximately 25 percent of the workforce is comprised of temporary workers who are used to satisfy daily, weekly, and quarterly surges in production requirements.

Digital's competitors for servers and workstations include Silicon Graphics, Hewlett-Packard, Compaq, Sun Microsystems, IBM, and Dell Computer Corp. It is a fiercely competitive market, and upstarts such as Dell are gaining market share by applying their lean, fast-paced manufacturing capabilities learned from low-cost PC production to higher-performance server and workstation manufacturing. For example, while Dell's server business contributed just 6% toward 1996 revenues, its market share grew 300% in that year alone.[1]

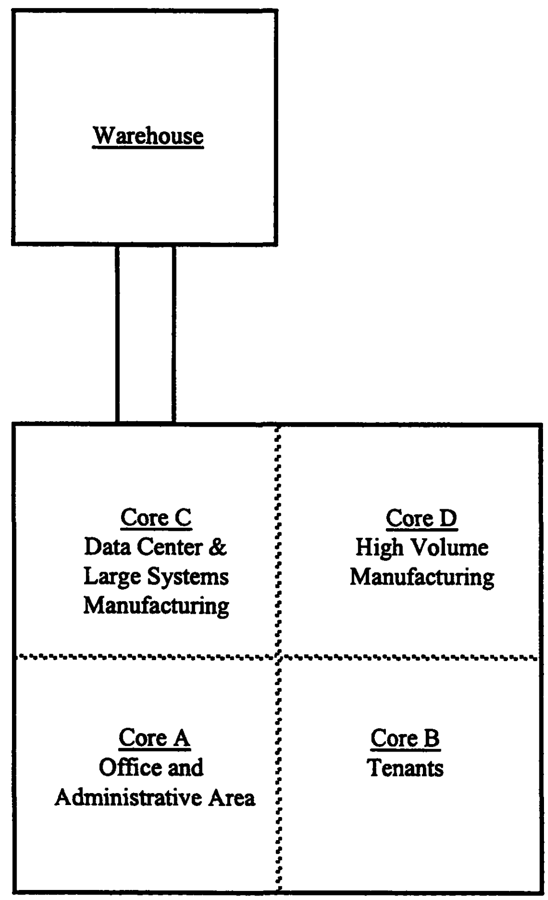
Factory Layout

The Salem facility is split into four "cores" (Cores A through D) plus a warehouse attached by a passageway. The plant has approximately 650,000 square feet:

- 130,000 square feet of administrative floor space (Core A);
- 120,000 square feet of floor space rented by Digital customers (or "tenants") (Core B);
- 250,000 square feet of manufacturing floor space (Cores C and D); and
- 150,000 square feet of warehouse floor space.

[1] McWilliams, Gary. Business Week. "Whirlwind on the Web." April 7, 1997.

A diagram of the facility is shown below:



Note: Factory not drawn to scale

Products

The products assembled at the Salem facility fall into three "families": Desktop, Deskside, and Data Center. As shown in the table below, the product name and the type of product further differentiate the product families. The Desktop family has ten different products, Deskside has six different products, and Data Center has five different products.

Product Family	Product Name	Product Type
Desktop	Miata	Workstation
	MX3	Workstation
	Avanti	Workstation
	Maverick	Workstation
	Pelican	Workstation
	Sandpiper	Workstation
	Mustang	Workstation
	Chinet	Server
	Pmariah	Client
	Cougar	Client
Deskside	Rawhide	Server
	Mikasa/Noritake	Server
	Demi Sable	Server
	Sable	Server
	Alcor	Workstation
	Flamingo	Workstation
Data Center	Argon	Server
	Turbo	Server
	Rawhide	Server
	Neon	Server
	Crypton	Server

Typically, servers are differentiated from workstations by the amount of storage capacity available and the amount of memory used for operation (servers use more of both). Because workstations are meant to support the work of one user at a time, they require only limited amounts of memory and storage. All products can be custom-configured to customer preferences. Because of the number of options, there are literally thousands of unique possible combinations of products.

In terms of size, Desktop products are roughly the same size as a personal computer. Accordingly, Deskside products are the size of a large television, and Data Center products are about the size of a refrigerator. All three product families use Digital's Alpha processor.

In addition to Deskside, Desktop, and Data Center products, the Salem facility assembles some components that go into these products. The highest volume component, the Storage Building Block (SBB), consists of a hard drive purchased from an external supplier and a special enclosure that allows it to be plugged into a cabinet or shelf containing an array of SBBs.

Collectively, Desktop, Deskside, Data Center, and SBB products constitute Digital's System Business unit (SBU) manufacturing organization. Desktop, Deskside, and SBB products are high volume products. Data Center products, due to their complexity and cost, are lower volume products.

Another manufacturing organization, the Computer Systems Solution (CSS) group produces highly customized and very complex large systems and is co-located in Core C with the Data Center manufacturing group. Together, the CSS group and the Data Center group constitute the Custom Integrated Computing (CIC) manufacturing group.

Current Issues Facing Salem

As a cost center, the performance of the Salem facility is measured against three crucial metrics:

1. Total product cost - Total product costs affect profit margins and pricing strategies; thus, the lower the total product cost, the better.

2. Order cycle time - At Digital, cycle time is defined as the total time it takes for the factory to complete and ship an order from the time it receives the order. It is also common in industry to refer to this metric as "order lead-time." Factors influencing cycle time include productivity levels, manufacturing processes, availability of raw materials, and staffing levels. It is easier for Digital to be competitive if it can meet or beat the relatively short order cycle times of its competitors.

3. Predictability - Digital customers, especially those buying larger, more expensive systems, place a high value on the predictability of an order delivery. Thus, it is crucial for Digital to deliver its products on the agreed upon date and time since failure to do so can result in secondary impacts for the customer. Complex system changes within companies are often tightly scheduled around the planned arrival date of new Digital equipment.

There are four key issues facing the Salem facility that adversely affect the three crucial metrics – (1) integration issues from manufacturing consolidation, (2) inadequate order predictability and long order cycle time, (3) inefficient inventory control, and (4) quarterly production volume skew. Each of these issues is discussed in more detail below.

Integration Issues from Manufacturing Consolidation

Over the past five years, a number of Digital manufacturing facilities have been closed and their operations moved into the Salem facility. In 1994, the workstation and server assembly plant in Albuquerque, New Mexico was shut down and all operations were transferred to the Salem facility. In 1995 and 1996, workstation assembly lines in Ontario, Canada and large system storage assembly lines in Colorado were also transferred to Salem. In all three cases, the transfers took place over only a few months and limited time was available to incorporate these manufacturing lines into Salem in an optimized fashion. As a result, the factory became packed with a disarray of manufacturing equipment and people, and floor space has become a rare commodity.

To complicate matters, the unique information system from each of the closed manufacturing sites was transferred intact and made operational in the Salem facility. Consequently, there currently exist several disparate and non-integrated information systems operating from a single site, leading to inefficient material control.

Inadequate Order Predictability and Long Order Cycle Times

Digital's average cycle time (i.e., from customer order to final shipment) is currently between 13 and 15 days, although there exists a firm-wide goal to reduce cycle time to five days or less. Meeting this goal, or at least decreasing the total order cycle time, would greatly improve Digital's ability to accurately predict order completion and delivery dates. Shorter cycle time reduces the chances of variables being introduced that could adversely affect production delivery dates.

According to a recent market study by Kaiser Associates, Digital is near the bottom of the competitive pool in terms of order cycle time and predictability. According to the study, Digital managed to deliver its products on or before the promised delivery date only 73% of the time.[2] The following table shows a comparison of average order cycle time (in days), as well as order delivery predictability for Digital and five of its competitors.

Company	Product Family	Avg. Order Cycle Time (days)	Predictability
Digital	Desktop	13	73%
	Deskside	15	73%
	Data Center	15	73%
Hewlett Packard	Desktop	12*	92%
	Deskside	12*	92%
	Data Center	22*	88%
Sun Microsystems	Desktop	10	82%
	Deskside	10	82%
	Data Center	18	80%
IBM	Desktop	9	93%
	Deskside	13	85%
	Data Center	13	97%
Compaq	Desktop	7	95%
	Deskside	7	90%
	Data Center	7	90%
Silicon Graphics, Inc.	Desktop	13	70%
	Deskside	30	80%
	Data Center	30	80%

(Source: Kaiser Associates)

* Measured from customer order to customer receipt of order. All other cycle times are from customer order to shipment of the order.

[2] Kaiser Associates. "Competitive Analysis of Order Lead Time and Delivery Predictability." Study presented to Digital Equipment Corporation, Maynard, MA. June, 1997.

Inefficient Inventory Control and Stock-Outs

The Salem facility has experienced significant and consistent problems with parts availability. Parts shortages lead to delays in manufacturing of customer orders. A prior analysis found that parts shortages were the primary reason Digital missed promised delivery dates.[3]

A number of possible reasons exist to explain the parts shortages. One reason may be poor management of suppliers. Digital managers may not be receiving accurate forecasts for material requirements, and thus, are unable to keep up with the demand for parts. Alternatively, suppliers themselves may be late in shipping and are thus unable to meet the forecasts given to them by Digital managers. A third reason may be that inventory is poorly controlled on the factory floor. Digital managers have noted that parts are often not available even when the inventory system claims they are. Conversely, parts are sometimes available when the inventory system claims they are not. It is also possible that parts shortages occur due to a combination of the reasons listed above.

Quarterly Production Volume Skew

Toward the end of each fiscal quarter, the volume of orders surges. There have been numerous attempts to understand and correct this phenomenon, but no one analysis has conclusively shed light on this problem. Management at Salem is focused on seeking ways to mitigate and/or compensate for it. Typically, 50% of the quarter's orders occur in the last month of the quarter causing a facility overload, which in turn results in an increase in orders arriving after their promised date.

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[3] Hopkins, Pat. Thesis for SM and MBA. MIT Leaders for Manufacturing Program, 1997. Cambridge, MA.

Objectives of the Reengineering Initiatives

To position Digital to meet world-class manufacturing standards, the Salem facility has set a number of goals for FY'98:[4]

<u>Inventory turns: An increase from 6.5 turns in FY'97 to 9.7 turns by Q4, FY'98</u>

By changing the way high-volume products are manufactured and the way inventory is stored on the floor (see Appendix C for detailed information on the Salem Assembly Module - "SAM"), Salem management hopes to become much more efficient in the use of inventory.

<u>Predictability improvement: An increase from 73% in FY'97 to 95% by Q4, FY'98</u>

There are a number of proposed initiatives to improve the order consolidation and shipping processes, described later in the document, that will reduce the total order cycle time and improve order delivery predictability.

<u>Total Manufacturing Costs: A 16% reduction</u>

By pursuing both the SAM initiative and the order consolidation and shipping initiatives, the Salem management hopes to reduce total manufacturing costs.

<u>Shipment Complete: An increase from 12% to 60%</u>

Currently, only 12% of the total orders are delivered from Salem directly to the customer. The remainder must first move through Digital's Dascomb Road facility before being shipped to the customer. This adds time and complexity to the order process. Shipping direct from Salem would eliminate this complexity and improve order delivery predictability.

[4] Annual Planning Report. Digital Equipment Corporation, Salem, NH. July, 1997.

Chapter 2 - Strategic Analysis of Functional Capabilities

Our approach to the Strategic Analysis consisted of three tasks:

- Interview members of the Steering Committee to better understand current processes and potential new functional capabilities;
- Create a high-level process mapping of material flows (involving supplier, factory, distribution center, and customer); and
- Assess the strategic implications of changing the functional capabilities of the Salem facility.

The team developed several criteria and associated questions to evaluate the potential new functional capabilities:

Strategic fit:	Does the proposed mix of manufacturing capabilities and services fit with Salem's and Digital's vision of where they want to be as a manufacturer and service provider?
Physical space and capacity:	Could the functional areas fit within the existing four walls of the Salem facility and still have room for significant capacity growth in the future?
Material flow intensity:	How would the proposed configuration affect the flow of material within the factory? Would it increase or decrease the amount of material handling and congestion?

In this context, "changing the functional capabilities of the factory" is defined as the ability for Salem to manufacture products it does not currently produce (e.g., PC's and circuit boards) or furnish services it does not currently provide (e.g., order consolidation and shipping).

Finally, we attempted to understand the fundamental question of how to change the functional capabilities of Salem such that order delivery predictability would improve and manufacturing cost would decrease. To understand what functions should be grouped together, we looked at expanding the Salem facility both vertically along the supply chain and horizontally across product families.

Horizontal vs. Vertical Integration

This section highlights the key advantages and disadvantages of horizontal and vertical integration of the Salem facility.

Vertical Integration - Possible Advantages

In her book, Modern Competitive Analysis, Sharon Oster states, "In considering vertical integration, an organization should consider costs and benefits netted across units, reflecting fully on opportunity costs."[5] As such, as a first step the design team developed a list of potential advantages if Salem were to become more vertically integrated:

- *Lead time and cycle time reduction.* By manufacturing more components on-site, Digital would be able to eliminate the time required to move raw material to the factory from the supplier. Time could also be saved by eliminating the trip finished goods take between the factory and the order consolidation and distribution center.
- *Lower manufacturing cost.* Similarly, there would be an opportunity to save transportation and transactional costs by eliminating a number of trips between raw material (component) suppliers and Salem and between Salem and the customer. Additionally, becoming more vertically integrated might allow Digital to eliminate the margins demanded by component manufacturers, thus reducing cost.
- *Reduced inventory.* Inventory buffers between component sources and the Salem facility used to prevent material shortages could be eliminated if some components were manufactured on-site as needed.
- *Improved feedback and quality control.* Having some components manufactured on the same site where the final products are assembled and tested would allow for rapid feedback to the component manufacturing areas, should there be a quality problem with the components. Component production could be stopped and the improvement process could begin immediately.
- *Improved predictability and better scheduling.* It would become easier for management to understand the actual length of time it needs to fill a particular order if there is visibility across a larger portion of the supply chain. Problems in the supply chain are much more

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[5] Oster, Sharon M. Modern Competitive Analysis. Second Edition. Oxford University Press, New York. 1994. P.199.

readily apparent if they occur locally. Consequently, the process of predicting order completion and delivery would be facilitated by local production of components.

- *Increased amount of material shipped direct to the customer.* As previously stated, one of the goals set for the reengineering of Salem is to be able to ship a much greater percentage of products directly to the customer from the Salem site. Performing order consolidation and option fulfillment and shipping on-site would allow this to happen.

Vertical Integration - Possible Disadvantages

A number of potential draw backs also exist if Salem were to be more vertically integrated:

- *Lack of local expertise.* Should management attempt to produce some of the components on-site, it might discover a lack of local expertise in the knowledge required to produce the given component. This could cause a slower implementation process and initially could create higher manufacturing costs until the necessary expertise is either brought in or learned.
- *Loss of economies of scale.* By pulling some of the component manufacturing or product consolidation and distribution business away from a facility that focuses solely on that particular business, Digital may find itself with higher costs in both Salem and the other functional areas since high fixed costs are now allocated across smaller product volumes in each location.
- *Opportunity cost of expanding more horizontally.* By taking up space in the factory for vertical integration, Salem would lose the opportunity to use that space for a horizontal expansion of its existing businesses.

Vertical Integration - Potential Changes

Given these advantages and disadvantages, the team developed a list of possible functional capabilities to make the facility more vertically integrated.

- *Modules.* The main circuit boards (modules) for all of Salem's deskside, desktop, and data center units could be produced in Salem. Module manufacturing currently takes place in Digital facilities in Singapore, Canada, and Scotland.
- *Software Procurement.* Software and documentation would be provided with all units produced at Salem. Software is currently procured from the Nashua, NH facility.
- *Order Consolidation and Shipping.* Once a unit is assembled, it would be sent to the order consolidation and shipping area to be placed with the other units of its order and then shipped out to the customer. Order consolidation and shipping currently takes place at the Dascomb Road facility in Andover, MA.
- *Non-Embedded System Options Fulfillment.* Optional components for a customer's order that are not assembled into the final product (i.e., "non-embedded") would be added to the order in the Salem facility. Currently, they are added to the shipment at the Dascomb Road facility.

The following chart summarizes the potential benefits of these new vertically-integrated functional capabilities at Salem:

Potential Benefits of Vertical Integration

	Lead time and cycle time reduction	Lower manufacturing cost	Reduced inventory	Improved feedback and quality control	Improved predictability and better scheduling
Upstream Integration:					
Module Manufacturing	√	?	√	√	√
Downstream Integration:					
Order Consolidation and Shipping	√	√			√
Non-Embedded Options	√	√			√
Software Procurement	√	√	√		√

Horizontal Integration - Possible Advantages

As would be expected, the team then developed a list of the potential advantages if Salem were horizontally integrated:

- *Lower cost due to economies of scale.* By manufacturing similar products together on the same site (e.g., workstations and PCs), the manufacturing cost per unit would decrease. Fixed costs could be amortized over higher product volumes. Also, higher volumes of similar products would facilitate better labor capacity and skill utilization, and training costs would be minimized, given the similarities of tasks.
- *Reduced inventory with common parts.* Similar products can often share a number of components, resulting in the need to stock proportionally fewer part numbers (e.g., PCs and workstations would be able to share components such as the chassis, networking modules, etc.)

Horizontal Integration - Possible Disadvantages

The potential disadvantages of horizontal integration at Salem are as follows:

- *Reliance on external suppliers for goods and services.* By focusing on a specific functional capability, the Salem facility would become more reliant on external suppliers for some necessary goods and services. This equates to less control and visibility of the supply chain, which could adversely impact order delivery predictability.
- *Opportunity cost of expanding more vertically.* By taking up space in the factory for horizontal integration, Salem would lose the opportunity to use that space for a vertical expansion of its manufacturing capabilities.

Horizontal Integration - Potential Changes

The functional changes that would be made at Salem if horizontal integration were to be implemented are as follows:

- *Volume Operations.* Besides adding more volume to the existing product lines in Salem, PC manufacturing would share the same type of assembly operation as the high-volume products in Salem, such as Desktop and Deskside workstations and servers.

- *Pick, Pack, and Ship Operations.* There are a number of different functions that share the same type of work. So-called "Pick, Pack, and Ship" operations involve picking a part or product from storage, placing it into a shipping container either by itself or with other items, and sending it to the shipping area. Software Procurement, order consolidation and shipping, and non-embedded system options fulfillment all require this similar set of tasks and thus would be candidates for horizontal expansion.

The following chart summarizes the potential benefits of each of the new functions:

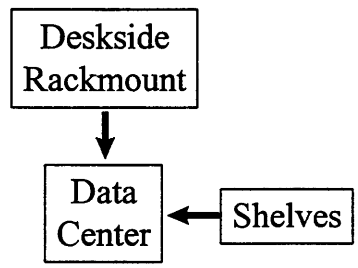
Potential Benefits of Horizontal Integration

	Lower unit cost due to economies of scale	Reduced inventory with common parts
Volume Operations: PC's	√	√
Pick, Pack, and Ship: Order Consolidation and Shipping	√	
Non-Embedded Options	√	
Software Procurement	√	

From the above discussion on horizontal and vertical integration, it is clear that there are a number of potential functional areas that could be added to Salem under both horizontal or vertical integration. Thus, after considering the advantages and disadvantages of horizontal and vertical integration, the team concluded that the final recommendation would most likely be some combination of both types of integration.

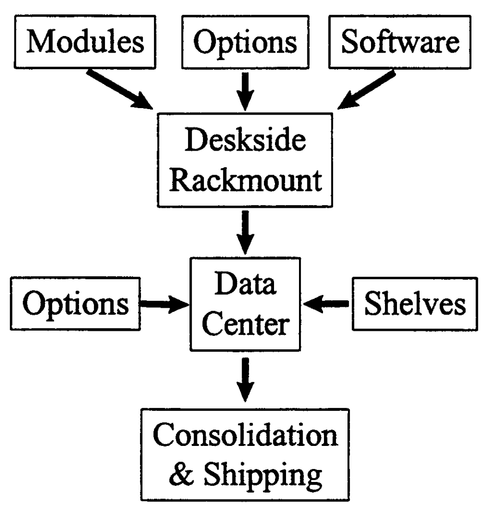
To test this theory, the team selected a Data Center product, the type of product that best represents most of the manufacturing processes that occur in Salem. In so doing, we compared Salem's span of control over the total supply chain before and after integration (both vertical and horizontal):

Before Integration - Areas Under Salem's Control:



To make a Data Center product, Salem must first assemble a deskside unit in a "rackmount" configuration, which is then placed into the Data Center cabinet. Salem also assembles the shelves of disk drives that become part of a large storage array within the Data Center unit. In this case, the modules that go into the deskside unit, the optional components that go both into the deskside unit as well as the data center unit, the software that goes into the deskside unit, and the order consolidation and shipping tasks, are all provided by facilities (either Digital or third party) outside of Salem. If these tasks were performed on-site at Salem, management's span of control over the supply chain would be as follows:

After Integration - Areas Under Salem's Control:



The team concluded that bringing order consolidation, shipping, and the option fulfillment business under Salem's control presented the best opportunity to assess the pros and cons of integration. Not only were the tasks in these businesses similar enough to get economies of scale (i.e., horizontal integration), they also allowed for a "downstream" vertical integration of the Salem business. Bringing these businesses under Salem's control would allow the facility to perform all of the above functions except for Modules and software.

As a result, more investigation into the order consolidation, shipping, and options fulfillment business was required. The first step was understanding how the existing processes currently function.

Consolidation, Shipping, and Options Fulfillment Process

As stated earlier, the main metrics used to judge the performance of the Salem facility are total product cost, order cycle time, and order delivery predictability. A careful analysis of the current order consolidation, shipping, and options fulfillment process based upon interviews with key members of Salem management revealed a number of opportunities to improve upon all three metrics. Under the existing process, material necessary to create a complete customer order comes from three sources:

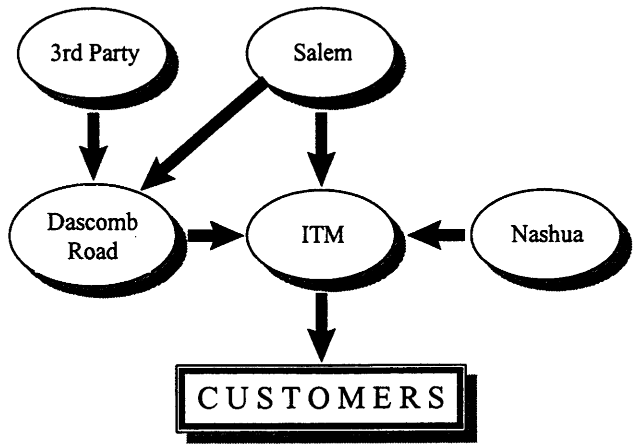
1. Third Party Suppliers: Suppliers sell hardware to be included as part of an order. For example, a third party makes monitors, a Digital logo is placed on them, and they are sold with many orders. Currently, the third party hardware is shipped to and stored in the Dascomb Road facility and can be included in an order as an option.

2. The Nashua, New Hampshire facility: This Digital site provides software and documentation for Salem orders. The software and documentation is sent directly to the In-Transit Merge (ITM) facility, which is operated by a single, external shipping agent.

3. Salem: Salem assembles the hardware for all orders and most of the options that are not purchased from a 3rd Party Supplier. The bulk of the system orders are sent to the Dascomb Road facility where they are matched up with the appropriate options for the order. Once the order is consolidated with the options, it is sent to the ITM site to be consolidated with the software from Nashua. All of the data center orders are sent directly from Salem to the ITM site, where they are consolidated with the software from Nashua and the options from Dascomb Road.

The diagram below describes the material flow:

The Order Consolidation, Shipping and Options Fulfillment Process, June '97



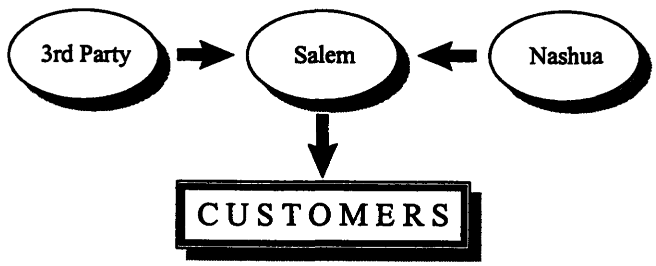
The complexity of the existing system adds time and cost to the customer order process. Cost and administrative expense are added by shipping system orders first to Dascomb Road and then to ITM before finally being sent to the customer. Often, an order is delayed because part of an order arriving from one of the three sources is missing or late. Consequently, the entire order is held in the ITM area until the missing or late part is delivered.

Proposed Consolidation, Shipping, and Option Fulfillment Process

If Salem could eliminate the In-Transit Merge function and perform the options fulfillment process in-house, the total order cycle time could be reduced by a number of days and a significant amount of cost could be eliminated. Digital could save money by eliminating the freight charges between Salem and Dascomb Road and by eliminating the In-Transit Merge process. The shipping agent currently charges Digital and Digital's customers for the work it performs to consolidate the orders. Thus, Digital could also save time by eliminating two of the three shipping legs by having the shipping agent take material directly to the customer from Salem.

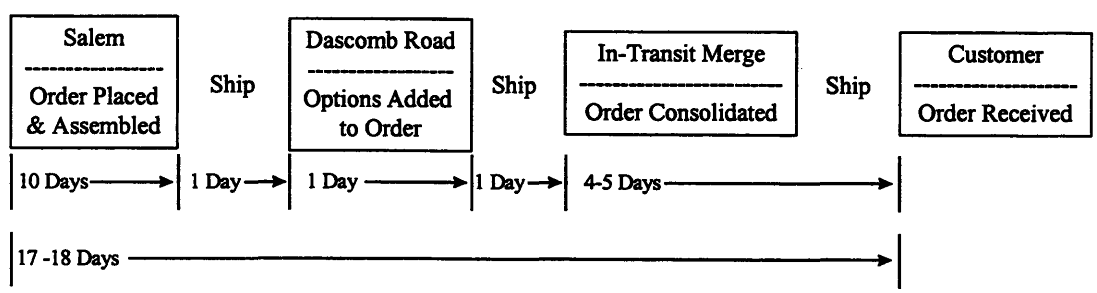
The proposed changes would affect the order consolidation, shipping, and options fulfillment process as follows:

The Proposed Order Consolidation, Shipping and Options Fulfillment Process



Under the proposed scenario, 3rd party suppliers of hardware would deliver directly to Salem, and all options for Salem products would now be stored on-site. The software and documentation from Nashua would now be delivered directly to Salem as well. Salem would perform all order consolidation, option fulfillment and shipping functions. Using a typical ordering process, the existing customer order shipping process is as follows:

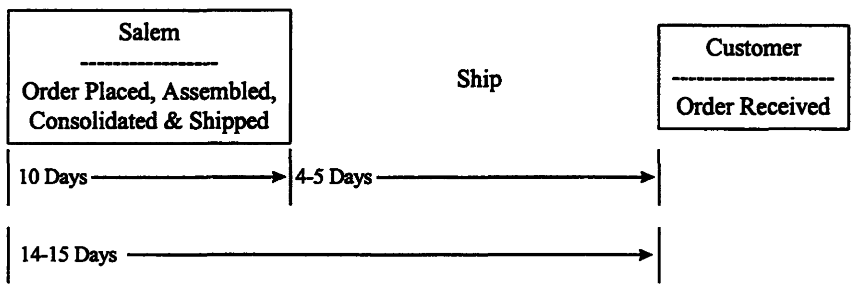
Existing Customer Order Shipping Process



(Note - The total order cycle time shown here includes the 4 to 5 days an order takes to reach the customer once it has left Salem's shipping dock. In Chapter 3 of the thesis, Salem's average order cycle time is quoted as being 13 to 15 days. This measurement ends as soon as the product leaves Salem's shipping dock and does not include the actual shipping time.)

After implementation of the proposed changes, a typical order would be as follows:

Proposed Order Shipping Process



In short, two to three days would be eliminated from the order shipping process and costs could be significantly reduced because of the simplification of the process. Thus, integration presents an opportunity for Salem and Digital to save money and improve operational performance through a combination of horizontal and vertical integration. As the above example illustrates, the strongest candidates for integration are (1) the order consolidation and shipping business, and (2) the system options fulfillment business.

In a June 1997 press release, Jeff McClees, a project manager at Hewlett-Packard captured the essence of why Salem should consider integrating order consolidation, shipping and system options fulfillment within its facility: "The push toward 'mass customization' in electronics makes it imperative that manufacturers be fast and flexible in responding to customer orders."[6] By having the options business on-site, Salem would be better able to perform the "mass customization" of its products in a more timely and cost-effective manner.

The next step in the analysis was to brainstorm on a number of different layouts for the Salem facility to include the addition of the proposed functional capabilities described above.

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[6] Business Wire. "Hewlett-Packard Implements Global MES Solution from Industrial Computer." June 16, 1997. Atlanta.

Chapter 3 - Factory Layout Analysis

Given the potential new functional areas, the team developed a list of five possible layout scenarios using a "greenfield" approach. The scenarios were then presented to the Steering Committee. After subsequent discussion, the Committee made a recommendation to pursue one scenario for further evaluation. The scenario selected was clearly the most feasible layout to implement, met the necessary criteria, and was not prohibitive for cost or time reasons. Additional analysis was thus performed to ensure that the design was indeed a good choice and to offer any additional improvements to the selected scenario.

Greenfield Design

In the narrowest definition of the term, the factory layout analysis was not a true greenfield exercise where there are no constraints on layout redesign. The team was constrained by having to work within the confines of the existing building, and limited resources did not enable to team to perform an analysis of the administrative work that occurred in Core A of the building. We were, however, free to explore changing, moving, and adding to the functional capabilities of the Salem facility within Cores B, C, D and the warehouse.

Each of the five greenfield layouts had to meet the following basic requirements:

1. All functional areas must be able to physically fit within the Salem facility;
2. The layout must offer space for expansion within Salem to meet growing demand for some products; and
3. The layout must result in synergies between products and functional areas that would lead to lower overall cost, lower cycle time, and improved predictability.

Using the list of potential functional changes for vertical and horizontal integration discussed in Chapter 4, the team developed five possible layout scenarios summarized in the table below:

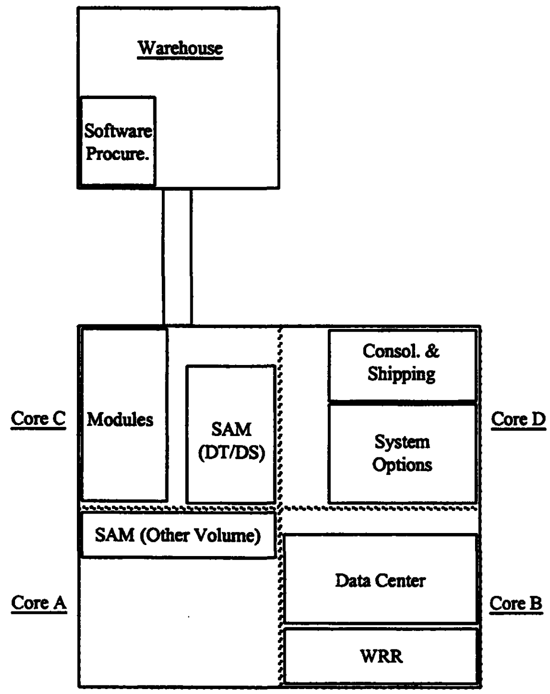
	New Functional Areas						
Scenario	Order Consolidation and Shipping	System Options Fulfillment	PC's or Other High-Volume Products	Modules for Salem and Other Products	Modules for Salem Products Only	Software for Salem Products Only	Software for Salem and Other Products
1	√	√	√	√		√	
2	√	√			√	√	
3	√	√	√		√		
4	√		√	√			
5	√	√					√

Interviews were conducted with individuals at Salem who were expert in each of the new functional areas. From these interviews, the team made their best estimates as to the necessary floor space requirements and best placement within the facility.

For example, in Scenario 1 the team determined that the volume manufacturing cells (Salem Assembly Module - SAM) would be expanded in capacity to produce the existing Desktops, Desksides, and potential new, high-volume products, such as PC's. These cells would be placed in both Cores A and C. The data center manufacturing area would be moved to Core B, and order consolidation and shipping and options fulfillment would be placed in Core D. Finally, software procurement would be placed in the warehouse and the module manufacturing capacity would be expanded to produce modules for Salem and other products. Under this scenario, dock doors would have to be added to Core D, and the tenants would have to be moved off-site.

A visual layout of Scenario 1 is shown below:

Scenario 1:



Each scenario was diagrammed in a comparable manner. However, in comparison to the other scenarios, Scenario 3 appeared to offer the most promise in meeting the Steering Committee's priorities and consideration of time, money and feasibility in implementing a new factory layout design.

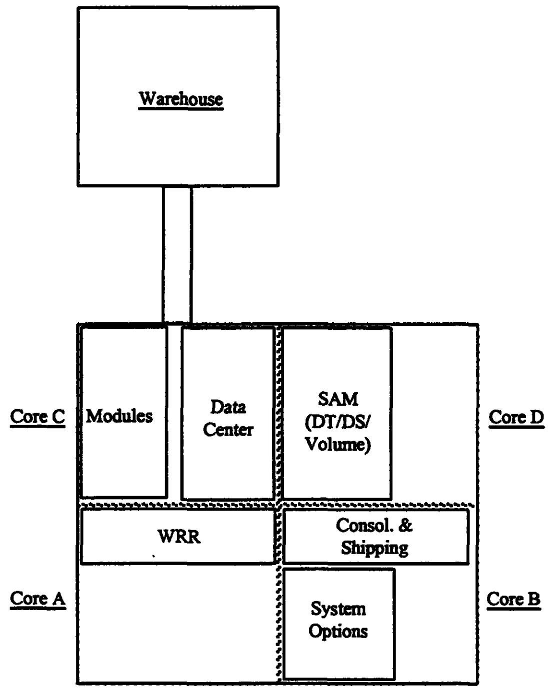
Scenario 3 offered the following functional capabilities for Salem:

- Existing Salem businesses
- Modules for Salem products only
- Dascomb Road's order consolidation and shipping business, known as "Stock Room 183" (SR183)
- Dascomb Road's systems options fulfillment business, known as "Stock Room 10" (SR10)

Scenario 3 enabled the team to place together functions that complemented each other, as well as offering Salem the most flexibility in terms of space for additional manufacturing capacity. Thus, the focus of the team's work was to complete further analysis to verify that Scenario 3 was indeed the best option.

The visual layout for Scenario 3 is shown below:

Scenario 3:



A more detailed analysis of the material flow needed to be performed by the team to ensure that the proposed layout would have a simple and logical flow of material through the facility to minimize material movement. At the same time, the team sought additional ideas to improve upon the selected design using a software package that helped analyze the thousands of material moves that occur each day at Salem.

Material Flow Analysis

To perform an operational analysis of the selected layout scenario, the design team used a software package called "Factory Flow." The software, created by the CIMTech Corporation of Ames, Iowa, is a material flow analysis and diagramming tool for layout design, justification, and presentation.

Factory Flow runs on top of AutoCAD™ and generates actual-path and point-to-point product flow diagrams. The varying thickness of the flow lines that are drawn by the software represent the amount of material being moved between two locations. Factory Flow also allows different layout scenarios to be compared graphically and analytically, enabling the user to compare scenarios on the basis of material flow intensity and overall material handling cost.

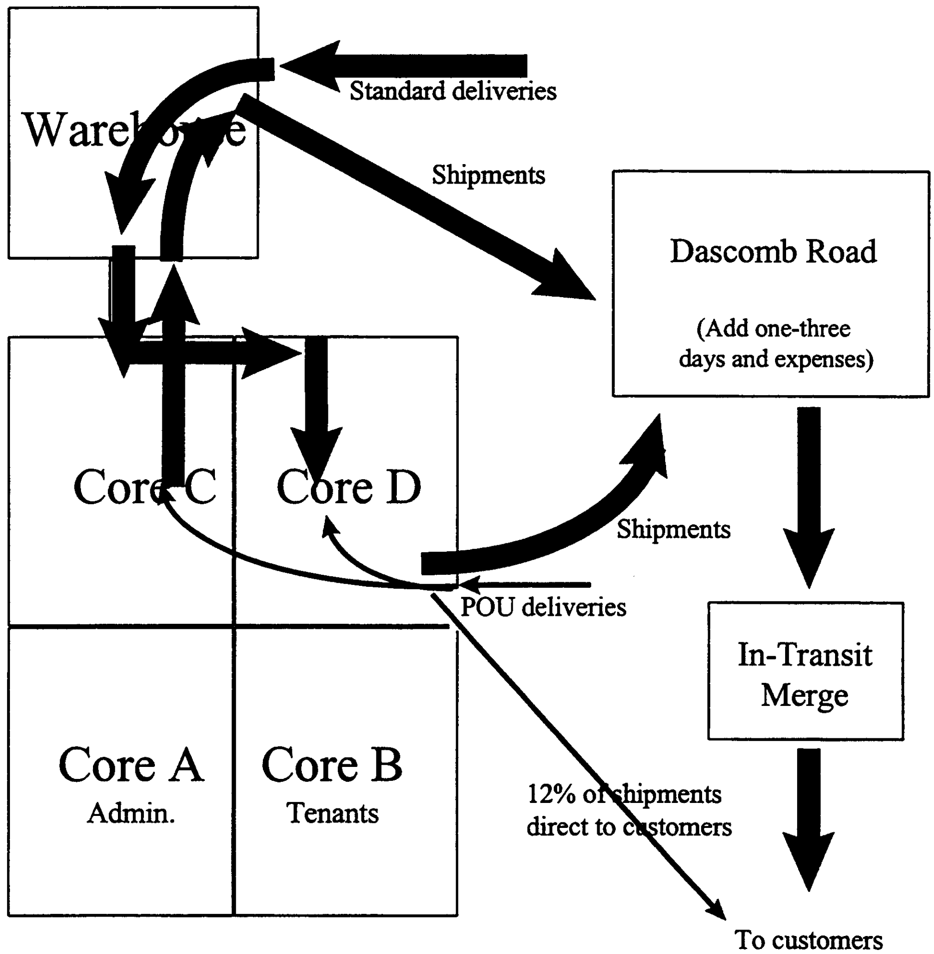
The Factory Flow model has eight stages to its design process:

1. Identify the goals of the study and determine the areas or products affected.
2. Determine the level of detail.
3. Adopt naming conventions for products, parts, material handling devices, and work-centers.
4. Gather and organize the input data.
5. Produce an AutoCAD plant drawing.
6. Integrate the drawing and the data.
7. Produce reports for analysis.
8. Analyze Reports and Make Recommendation

A more detailed description of the model and Steps 1 through 8 is included in the Appendix.

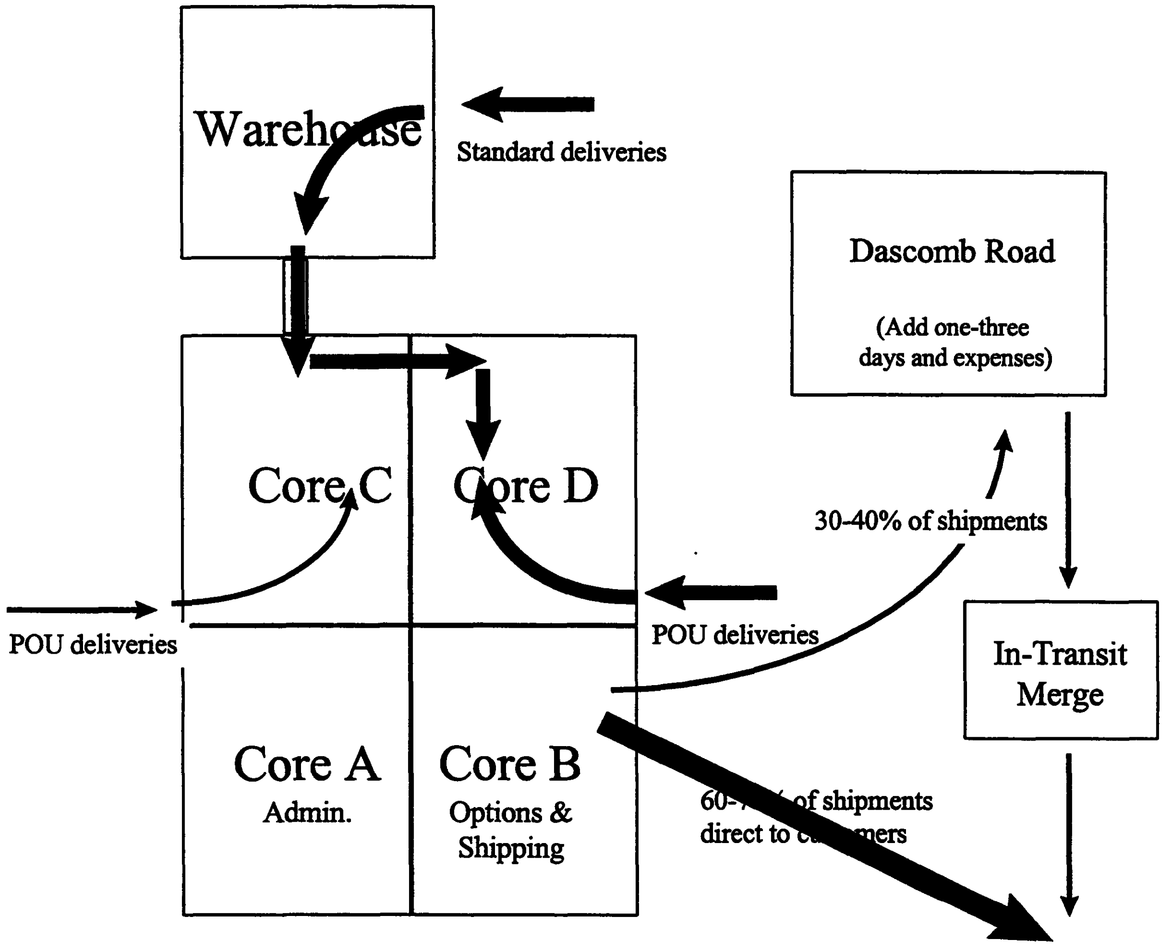
The following diagrams represent the differences in material flow under the existing (June 1997) factory layout and under the recommended factory layout (Scenario 3). These diagrams are a simplified version of the actual Factory Flow diagrams, which are included in Appendix A.

June, 1997 Layout:



As of June 1997, larger server manufacturing functions were split between the Data Center manufacturing area (Core D) and the Computer Systems Solution (CSS) manufacturing area (Core C). System Options were procured from the Dascomb Road facility, where the order consolidation and shipping functions were also performed. The vast majority of the components were received into the warehouse and then moved to the floor as necessary. Finally, a large number of shipments were performed out of the warehouse and out of Core D, contributing to a complicated flow, with material traveling in two directions through the same areas.

Recommended Layout:



In the recommended layout, the tenants would be moved out of Core B, and would be replaced by the options fulfillment business (SR10) and the order consolidation and shipping business (SR183). Options would be received through Core D dock doors. Enclosures would be delivered to Salem near the Point of Use (POU) through Core C, and disks and shelves would be delivered through Core D dock doors. To accommodate the increased load placed on the facility by having consolidation and shipping in Core B, additional doors would need to be added next to the existing doors in Core B (see the next chapter, "Factory Capacity Analysis"). No shipping activity would be performed out of the warehouse or out of Core D, thereby simplifying the material flows in those areas.

Based on the analysis completed using the Factory Flow model, the team verified that the recommended layout (Scenario 3) would allow for a much simplified flow of material through the facility as the initial layout analysis had indicated. Where there were large amounts of material flow between two functional areas, the model showed that these areas would indeed be in close proximity to each other. Likewise, the model determined that no areas existed where material would be flowing both into and out of the facility. The resulting factory layout was thus simplified and the flow of material more logical given the objectives and the established criteria.

Specifically, the team recommended that the following actions be taken at Salem to ensure a superior flow of material:

1. All options should be received through the Core D dock doors.
2. High volume components, such as disks, shelves, and enclosures should be received into the factory through the dock doors nearest their point of use.
3. All shipping activity should take place through Core B dock doors

In short, the expected net result of the factory layout changes is as follows:

- 20% reduction in the total annual number of feet material is moved between receiving and assembly[7];
- 2-3 day reduction in the total order cycle time;
- Significant cost savings due to the elimination of some shipping activities (see Chapter 7, "Financial Impact Analysis"); and
- Increased visibility of the total order manufacturing process and increased predictability of order deliveries.

Because of the change in material flow into and out of the facility, the team's next task was to determine precisely how much capacity the facility would need at its shipping and receiving areas, i.e., how many dock doors would be needed under the new factory layout.

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[7] Because the recommended factory layout includes several new functions, such as order consolidation and options fulfillment, these activities were not included in the comparison.

Chapter 4 - Factory Capacity Analysis

The primary purpose of the factory capacity analysis was to better understand how the proposed functional changes would impact the flow of material into and out of the facility (versus within the facility as discussed in the previous section). More specifically, the analysis sought to help the team understand how much capacity would be required to eliminate or at least minimize the chance of the shipping and receiving areas becoming bottlenecks. For both the inbound and outbound models, fairly simple spreadsheets were created to calculate the number of required doors. The main challenge in each model was to obtain accurate data and to establish reliable assumptions.

Inbound model

The inbound capacity model was created to determine the required number of dock doors at the warehouse for current and future manufacturing volumes.

Methodology

The model was based upon material receipt data from Q3 and Q4 FY'97, which covered the periods of greatest activity for Salem in a fiscal year. The data collected consisted of the daily total receipts for number of manifests, number of pieces, and number of pallets. "Pieces" are defined as any item not included on a pallet. Typically, pieces are small boxes of components. The model also used data collected from a time study of a number of receiving activities. Finally, there were several assumptions made regarding the availability of dock doors, based on a number of observations, and the effect of "Personal, Fatigue, and Delay" (PF&D). These are described in the "Assumptions" section below.

The method used to calculate the number of doors breaks apart the receiving activity into its component activities: bringing the truck to the door, unloading the pallets, unloading the boxes (pieces), and pulling the truck away from the door.

The formulas used to calculate the required number of doors were as follows:

$$\#Doors = Roundup\left(\frac{TotalDockMinutes}{(AvailableMinutes \times Utilization)}\right) + 1$$

$$TotalDockMinutes = \frac{(\#Trucks \times PullInPullOut + \#Pieces \times Time/Piece + \#Skids \times Time/Skid)}{ManagementFactor}$$

$$\#Trucks = \frac{\#Manifests}{1.6}$$

The "#Doors" calculation was rounded up to the nearest whole integer and then increased by one. According to the receiving manager, one door must be dedicated to last-minute "emergency" needs, such as FedEx and UPS deliveries of parts for orders that are short certain components.

For the "#Trucks" calculation, a week's worth of receiving activity was sampled to determine that, on average, there are 1.6 manifests per truck. Thus, the historical manifest data could be used to determine how many trucks came to the receiving docks each day.

Assumptions

The team made the following assumptions and definitions in the model:

Pull-in, Pull-Out: This is the total time it takes a truck to pull up to a dock and away from a dock, and includes all activity before the first piece is removed from the truck and after the last piece is moved into the truck. The sampled average was 15 minutes.

Time/Piece: This is the time it takes to unload an item from the truck that is not on a pallet. The sampled average was less than 1 minute.

Time/Skid: This is the time it takes to unload a pallet from a truck. The sampled average was less than 3 minutes.

Management Factor: This factor accounts for breaks and for PF&D (personal, fatigue, and delay). This factor was assumed to cause a 20% increase in required time to unload pallets and pieces – thus, a management factor of 1.2.

Available Minutes/Day: The doors are available 2 shifts per day, eight hours per shift (960 minutes).

Dock Door Utilization: The factor is used to account for both simultaneous arrival of trucks and the queuing that results, as well as the periods of inactivity at the door that follow because of uneven loading at the doors. This figure is based upon an average of samples taken at the warehouse dock doors and was estimated to be 60%.

Annual Revenue Growth: The assumption was made that revenue is proportional to the amount of raw material moving into the factory, and thus, proportional to the dock door capacity required. The projected growth rate is 15% for Salem.

Confidence intervals: Confidence intervals of 95% are used to calculate the number of doors required. This means that twice the standard deviation is added to the average calculated dock door requirement.[8] This should be sufficient to cover any spikes in receiving and shipping activity. The sampled data represents the period in Salem of highest annual activity, namely, the third and fourth quarters of the fiscal year. Also, the model assumes only a five-day, two-shift operation. Any spikes in activity in excess of the mean plus 2 times the standard deviation can be accommodated by adding a shift or working on the weekend. There is also additional capacity available by managing the shipping and receiving process more effectively so that the door utilization increases and the management factor decreases.

Results

Before any final results could be calculated, there were a number of questions that needed to be addressed (see Appendix B for a detailed description of the receiving volume analysis):

- Is there a significant skew to the volume of material being received by day, week, or month?
- If such a skew exists, how should we accommodate it?
- Are there types of shipments that are different enough from others (in terms of activities performed and total time required) to nullify the assumption that all shipments, on average, take about the same amount of time?

By looking at the receiving data broken down by type of shipping agent (large 18-wheel trucks loaded with skids versus small trucks delivering packages of components), we were able to determine the characteristics of the majority of receipts. We also analyzed the historical variations in the number of receipts of trucks, skids, and pieces (boxes). We drew the following conclusions:

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[8] Hogg, Robert V. and Johannes Ledolter. Applied Statistics for Engineers and Physical Scientists. Macmillan Publishing Company. New York. 1992.

- The small truck receiving activity in the warehouse represents only about 10% of the total trucking activity at the warehouse. 90% of the activity involves large 18-wheel trucks. Thus, the model was based entirely upon the time characteristics of the larger trucks.
- During the first week of each fiscal quarter, there is a significant decrease in truck activity.
- With the exception of the lull at the beginning of each quarter, the daily volume of trucks remains relatively constant. There is no skew for receiving activity.
- There is a spike in small packages received at the end of each quarter. This is due to the factory expediting small parts to finish orders before the end of the quarter. However, the volume of trucks remains relatively constant during this period.
- Adding one door to the total door requirement calculation and dedicating it to last-minute "emergency" needs would help prevent bottlenecks from occurring due to the end-of-quarter volume increase.
- The mean plus 2 times standard deviation upper limit should be sufficient for calculating the required number of doors.

Thus, by using the mean plus 2 times standard deviation method and adding one to the total, the inbound capacity model determined that the required number of dock doors for receiving in the warehouse was **six (6)**. Currently, there are six doors in the warehouse, so no doors needed to be added. The details behind this analysis can be found in Appendix B.

Outbound model

The outbound capacity model was created to determine the required capacity of Core B for current and future manufacturing volumes.

Methodology

Similar to the inbound model, the outbound model was based upon shipment data from Q3 and Q4 FY'97. The data collected consisted of the weekly total number of high-volume (Deskside and Desktop) system units shipped and lower-volume Data Center units shipped. From this data and a number of assumptions (see next section), we calculated the total number of doors that would be required using a comparable method as the inbound model: historical mean plus 2 times standard deviation, rounded up to the next whole number.

The formulas used to calculate the required number of doors for the outbound model are as follows:

$$\#\,Doors = Roundup:\left(\frac{\#\,Trucks \times TruckTime \times ManagementFactor}{(AvailableMinutes \times Utilization)}\right)$$

$$\#\,Trucks = \left(\frac{\#\,VolUnits}{\#\,VolUnits\,/\,Pallet \times \#\,Pallets\,/\,Truck}\right) + \left(\frac{\#\,CICUnits}{\#\,CICUnits\,/\,Pallet \times \#\,Pallets\,/\,Truck}\right)$$

Assumptions

The following assumptions were made for the outbound capacity model:

<u>Number of Volume Products per Pallet</u>: A pallet can a hold a maximum of 8 Desktops and 4 Desksides, but the typical customer order does not include the maximum number of these units. From the data, we made an assumption was that on average, three units are loaded onto a pallet before being shipped. This assumption enabled the team to calculate the equivalent number of pallets required to satisfy the outbound flow of volume products (Desksides and Desktops).

<u>Number of CIC Products per Pallet</u>: The assumption made was that one CIC product maximum can fit on a pallet, since these products are quite large.

Number of Pallets per Truck: A full 18-wheel truck can hold 20 pallets, and the assumption made was that all trucks used for shipping are 18-wheel trucks and are completely filled before leaving the shipping dock.

Average Truck Time at Door (min): Based on sampled data, a truck spends 50 minutes on average at the shipping dock.

Available Minutes/Day: Same as inbound model: 960 minutes per day.

Management Factor: Same as inbound model: 20% buffer for personal, fatigue, and delay, or a factor of 1.2

Door Utilization: Same as inbound model: 60% utilization.

Confidence interval: Same as inbound model: 95% equals the mean plus 2 times standard deviation.

Results

Before any final results could be calculated, we had to answer the same issues of volume skew that were addressed for the inbound model.

By plotting the historical shipping activity, our goal was to understand the nature of shipping behavior and to verify that the method of using the mean plus 2 times standard deviation was adequate and appropriate for calculating the required number of doors. (Please refer to Appendix B for detailed information on the shipping volume analysis.)

There were a number of conclusions that were drawn from the historical shipping data:

- Having eight (8) doors total should be more than enough to handle even the periods of highest volume.
- There is a significant upwards trend in shipment volume during the end of Q4 FY'97.
- The high-volume products represent 80% of the shipping activity, while the lower-volume Data Center products represent only 20% of the shipping activity.

By using the mean plus 2 times standard deviation and then rounding this result up to the next whole number, the analysis showed a total of eight (8) doors were necessary given the factory's shipping requirements. There are currently three doors in Core B, so five doors would have to be added.

Recommendations for Capacity Modeling

After creating the two capacity models, the team performed a "reality check" by presenting the results to the shipping and receiving managers. They were comfortable with our results and had previously independently recommended the same number of doors to the senior management of Salem. Their recommendations were based on experience, not quantitative models, yet it was reassuring to have another set of recommendations match the team's recommendations.

The analysis completed in the previous two sections was relatively simple, although enough "buffers" were built into the models so that the recommendations were made using relatively conservative assumptions, and call for perhaps more capacity than is immediately necessary. The models also assume all processes are performed in the same manner in the future as they are now. Thus, there are a number of opportunities to improve inbound and outbound capacity of the plant without adding additional doors.

A summary of the capacity analysis recommendations is as follows:

- The warehouse (inbound) needs six (6) doors total; shipping (outbound) needs eight (8) doors total.
- Salem should work with the shipping providers more closely and attempt to schedule the arrival and departure of trucks so as to avoid any excess multiple arrivals, that result in queuing and wasted time. This would significantly increase the door utilization.
- Material should be moved from the loading/unloading area directly in front of the dock doors as quickly as possible. This would eliminate the problem of full trucks unable to deliver their goods because of a lack of space on the floor in front of the dock door.
- Because the volume products constitute 80% of the shipping activity and because they are much smaller than CIC products, there may be a better way to ship them than stacking them on pallets and loading them into large trucks. Smaller trucks that spend less time at the doors could take away smaller loads of boxes, eliminating the need to queue up enough material to fill a truck before shipping. This would decrease the total order cycle time to the customer and increase dock door utilization.

Chapter 5 - Financial Impact Analysis

As stated previously, the overall strategic and financial impacts on a factory-wide basis (versus a project-specific basis) had not been evaluated for all the changes taking place currently at Salem. This chapter describes each element in the reengineering of Salem and the total financial and operational impact of these initiatives.

Most of the work in this chapter is the result of a collaboration with members of Salem's Reengineering Steering Committee, which is composed of the factory's senior management, and with several individuals from the factory's finance department. From this collaboration, the team created a document known as a "Capital Appropriations Request" (CAR). The CAR was presented to Digital in November 1997 to justify the capital requested to make the proposed reengineering changes. The bulk of the CAR consisted of a financial and operational analysis of five different iterations and a recommendation as to which iteration to pursue. Digital Corporate approved the requested funds in late November.

Reengineering Initiatives

The purpose of the proposed reengineering changes is to allow Salem to be more vertically integrated. Most importantly, the reengineering activities are expected to improve inventory control and decrease total manufacturing and distribution costs.

The reengineering projects include the following:

Layout Changes:

- Move Tenants out of Salem
- Add five dock doors to Core B (for a total of eight doors)
- Consolidate of several small functions to Core A

Functional Capability Changes:

- Move Dascomb Road's order consolidation and shipping business (SR183) to Core B
- Move Dascomb Road's systems options fulfillment business (SR10) to Core B

Operational Changes

- Implement of the Salem Assembly Module (SAM) for all High-Volume Products
- Expand Module Capacity (Pending Digital Management Decision)

Please refer to Appendix C for a detailed description of each reengineering element. (Note - The reengineering of Salem does not address any re-layout or reorganization of the administrative areas in Core A.)

Benefits

The various reengineering initiatives would enable the Salem factory to realize a number of benefits, namely:

- Total average order cycle time would be reduced to 14 - 15 days from 17 - 18 days.
- Salem would have a higher chance of achieving the goal of improving order delivery predictability to 91%.
- Salem, under the Salem Assembly Module (SAM) initiative, would have more manufacturing flexibility with manufacturing cells capable of rapid change-overs.
- With Core B cleared, Salem would have space available for expanding the manufacturing, consolidation, and distribution businesses.
- Finally, there would be significant cost savings due to efficiencies gained in labor utilization, reduction in inventory, and elimination of certain shipping activities.

A standard discounted cash-flow (Net Present Value) method was used to evaluate the financial benefits of the reengineering initiatives.[9] The NPV was calculated over five years with a discount rate of 20%. From Salem's perspective, the NPV was calculated only to show how the investments would affect the internal financial performance of the facility. The NPV calculation is of most value to Digital, where the costs and savings to the corporation. The primary difference between the Salem NPV calculation and the Digital calculation is the loss from Salem's P&L of the tenant rent (for the use of Core B). Digital as a whole would not lose the tenants' rent, as tenants would move to another Digital facility.

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[9] Higgins, Robert C. Analysis for Financial Management. Irwin, Inc. New York. 1995.

When the costs and savings of the reengineering projects are calculated, the financial return to Digital was determined to be:

- Net Present Value (NPV) to Digital: $8.0M
- NPV to Salem: $3.3M
- Pay-back period: 14 months

Risks

If the integrated reengineering program were denied, Salem would be incapable of completing the SAM implementation. There would not be sufficient floor space in which to place the final SAM cell. In addition, there would be no room to bring the System Options business from Dascomb Road to Salem, so Salem would be unable to ship complete orders directly to the customer. As a result, nearly all orders would continue to go through In-Transit Merge and Dascomb Road before reaching the customer. Finally, Salem would continue to suffer from bottlenecks in the shipping/receiving areas during periods of high activity due to inefficient material flows within the factory. Thus, while Salem may be able to make incremental improvements in performance without making significant changes to its infrastructure, only the successful completion of the reengineering initiative allows Salem to be able to make great gains in performance.

Alternatives

A financial impact analysis of five iterations of the recommended reengineering plan was performed as part of the Capital Appropriations Request. The analysis also assessed the sensitivity of the financial impact of not completing some of the planned changes. (For example, what if the facility to which the tenants were scheduled to move were suddenly unavailable and there was no place else to move the tenants?)

Thus, the iterative analysis consisted of analyzing the impact of the following different actions:

Move the tenants off-site: This is the planned course of action.

Compress tenants in Core B: If the tenants could not be moved, their current layout could be changed so that they use less space, freeing up space to be used for other functions.

Add an addition to the Salem building: This would provide additional space for new functions, should the tenants not be able to move.

Do nothing: This iteration accounts for a situation where the tenants are unable to move and unable to compress their floor space, and Salem does not receive the money to construct an addition to the existing factory.

There are four different results, with corresponding NPV's for Digital and for Salem:

Shipping in Salem: Even if nothing else changes, Salem would still be able to have the shipping function on-site.

Options in Salem: This is the planned course of action.

Complete SAM implementation: The first four iterations in the financial impact analysis allow for a complete SAM implementation.

Partial SAM implementation: This only occurs under iteration 5 (the "do nothing" iteration), where there is not enough space available to finish implementing all the SAM manufacturing cells.

A description of each iteration, including its advantages and disadvantages, can be found below. See Appendix C for a financial summary and analysis of each iteration.

	Action				Result					
Financial Impact Iteration	Move Tenants off site	Compress tenants in Core B	New Building	→	Shipping in Salem	Options in Salem	Complete SAM	Partial SAM	NPV, Digital ($millions)	NPV, Salem ($millions)
1	x			→	x	x	x		$8.0	$3.3
2		x	x	→	x	x	x		$5.2	$4.5
3		x		→	x		x		$8.3	$7.2
4			x	→	x	x	x		$3.5	$3.6
5				→	x			x	$7.1	$6.9

Iteration 1:

	Action				Result					
Financial Impact Iteration	Move Tenants off site	Compress tenants in Core B	New Building	→	Shipping in Salem	Options in Salem	Complete SAM	Partial SAM	NPV, Digital ($millions)	NPV, Salem ($millions)
1	x			→	x	x	x		$8.0	$3.3

This is the iteration Salem management has selected to pursue. Iteration 1 not only has the second highest Net Present Value for Digital, but from an operational perspective, it also best aligns Digital's manufacturing strategy with Salem's capabilities. This iteration allows Salem to ship 60-70% of its orders direct to the customer to reduce total order cycle time, and total cost, and improve order predictability. It also allows a complete implementation of the SAM cells across all high-volume products. Finally, this iteration positions Salem for significant growth in the future with room to accommodate more SAM manufacturing cells and the possibly of manufacturing modules for all Salem products.

Iteration 2:

	Action				Result					
Financial Impact Iteration	Move Tenants off site	Compress tenants in Core B	New Building	→	Shipping in Salem	Options in Salem	Complete SAM	Partial SAM	NPV, Digital ($millions)	NPV, Salem ($millions)
2		x	x	→	x	x	x		$5.2	$4.5

Iteration 2 would add an addition to the main building and move a large portion of administrative activities into the new building. The tenants' footprint would be reduced in Core B, and shipping and options would be placed in Cores A & B. While iteration 2 offers nearly all the benefits of iteration 1, the return to Digital is also not as large due to the costs of the new building construction.

Iteration 3:

	Action				Result					
Financial Impact Iteration	Move Tenants off site	Compress tenants in Core B	New Building	→	Shipping in Salem	Options in Salem	Complete SAM	Partial SAM	NPV, Digital ($millions)	NPV, Salem ($millions)
3		x		→	x		x		$8.3	$7.2

While iteration 3 has the most favorable Net Present Value both to Digital and to Salem, it does <u>not</u> allow for any significant expansion in manufacturing capacity. This is a large opportunity cost not reflected in the Net Present Value. This iteration also does not allow Salem to ship directly to its customers because the Systems Options business would remain at Dascomb Road.

Iteration 4:

	Action				Result					
Financial Impact Iteration	Move Tenants off site	Compress tenants in Core B	New Building	→	Shipping in Salem	Options in Salem	Complete SAM	Partial SAM	NPV, Digital ($millions)	NPV, Salem ($millions)
4			x	→	x	x	x		$3.5	$3.6

In iteration 4, the tenants would be moved to a new building addition at the main Salem facility, and the shipping and options business would be moved to Core B. Like iteration 2, iteration 4 is more expensive than iteration 1 and offers no additional benefits.

Iteration 5:

	Action				Result					
Financial Impact Iteration	Move Tenants off site	Compress tenants in Core B	New Building	→	Shipping in Salem	Options in Salem	Complete SAM	Partial SAM	NPV, Digital ($millions)	NPV, Salem ($millions)
5				→	x			x	$7.1	$6.9

Iteration 5 is essentially the "do nothing" option. If the tenants remain in Core B and shipping remains where it is currently (temporarily placed in Core D), the SAM implementation would be incomplete, since the addition of the SAM shelves cell would be impossible. It also does not position Salem for any growth, and because the systems options business remains at Dascomb Road, Salem cannot ship directly to its customers.

Recommendation from Financial Analysis

The main criteria in evaluating whether or not the current reengineering initiatives at Salem are financially and operationally beneficial is if Salem is able to meet the performance goals set for FY'98, which are as follows:

- Inventory turns: increase from 5.4 to 7.5
- Predictability improvement: increase from 70% to 91%
- Manufacturing Costs: 16% reduction
- Ship directly to the customer: increase from 12% to 60% of all orders

Other important success factors include:

- Timely implementation of changes
- Staying within projected costs

Because Iteration 1 allows Salem to ship 60-70% of its orders directly to its customers, allows for a complete implementation of all SAM cells, creates enough factory space for Salem to be positioned for future growth, and realizes a high NPV, it was determined that this iteration was the best strategy to pursue.

Chapter 6 - Conclusion

In their article entitled, "When and When not to Vertically Integrate," Stuckey and White explore the issues behind vertical integration decisions.[10] The authors present four reasons for vertical integration:

1. The existence of a risky and unreliable market;
2. As a defense against market power;
3. To create and exploit market power; and
4. As a response to industry life cycle dynamics.

While the recommendations in this thesis do not require Digital Equipment Corporation to become more vertically integrated, they do suggest a consolidation of activities into the Salem facility, such that *within* Digital, the Salem facility becomes more vertically integrated. Using Stuckey and White's reasoning for vertical integration, one could make strong arguments in defense of vertical integration for the Salem facility:

- The workstation and server markets have proven to be risky and unreliable; demand can surge during the last quarter of a fiscal year and plummet during the first quarter of the next year. Having increased visibility and control over the supply chain will allow Salem to respond more quickly, accurately, and efficiently to swings in demand.
- By pulling new functions into the Salem facility, the business will be better able to defend and exploit market power through reduced costs and cycle time as well as improved order delivery predictability.
- Finally, because the life cycle of workstation and server products is relatively short (often less than 18 months), having more of the shipping and options business on-site will ensure a minimum level of inventory is kept on-hand. This change will help Salem avoid having to write-off excess amounts of obsolete inventory when new products replace old ones.

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[10] Stuckey, John and David White. "When and When Not to Vertically Integrate." Sloan Management Review, Vol. 34 No. 3, Spring 1993: 71-83.

In conclusion, the following recommendations are made to improve the financial and operational performance of the Salem facility:

- **Place the option fulfillment, order consolidation, and shipping functions in Core B.** This would allow for superior material flows through the facility, as well as a reduction in total order fulfillment cost, order lead-time, and an increase in order delivery predictability.
- **Move the tenants to another Digital facility.** This would provide adequate space for the newly transferred functions in Salem.
- **Add five dock doors next to the existing three doors in Core B.** To perform all shipping activity out of Core B, a total of eight dock doors will be necessary to meet current and future capacity requirements. No additional dock door capacity will be required for the receiving function in the warehouse area.
- **Use the dock doors nearest to the assembly activity for receipt of high volume components.** The amount of material handling can be reduced by 20% by bringing some high-volume items to the floor using the dock doors nearest to the assembly activity.
- **Receive all options through Core D dock doors.** Material flow would be minimize by using doors in Core D near the System Options Fulfillment area. Receiving material through Core B doors is not recommended.
- **Use Core B dock doors for all shipping activity.** Again, this would allow for superior material flows out of the facility.

In addition, there are a number of tasks that were outside the scope of this thesis, but should be pursued to continue improving the operational performance of the Salem facility:

- **Perform a detailed evaluation of the costs and benefits of manufacturing circuit boards on-site.** By becoming more vertically integrated by manufacturing modules (circuit boards) for all Salem products on-site, a number potentially large benefits exist, but such an evaluation was beyond the scope of this thesis.
- **Work with the shipping providers to schedule the arrival and departure of trucks.** A schedule for trucks would help avoid any excess multiple arrivals, which result in queuing and wasted time and would significantly increase the door utilization.

- **Investigate using smaller trucks more frequently in the shipping area.** Because the high-volume products constitute 80% of the shipping activity and because they are much smaller than the Data Center products, there may be a better way to ship high-volume products than stacking them on pallets and loading them into large trucks. Smaller trucks that spend less time at the doors could take away smaller loads of boxes, eliminating the need to queue up enough material to fill a truck before shipment. Such a change would decrease the total order cycle time to the customer and increase dock door utilization.

Appendix A - Description of CIMTech Material Flow Analysis

There were eight stages in the material flow analysis of the Factory Flow model:[11]

1. Identify the goals of the study and determine the areas or products affected.
2. Determine the level of detail.
3. Adopt naming conventions for products, parts, material handling devices, and work-centers .
4. Gather and organize the input data.
5. Produce an AutoCAD plant drawing.
6. Integrate the drawing and the data.
7. Produce reports for analysis.
8. Analyze Reports and Make Recommendation

Goals of the Analysis

The goal of the design team was to use Factory Flow to ensure that the recommended layout was a superior way to layout the new functional capabilities at Salem. If any serious problems or issues with the recommended layout arose, the design team would have focused on finding an alternative solution.

Level of Detail

Because of time constraints, the team focused only on the location of the major functional "blocks" within the factory. For the existing factory, these blocks included:

- Salem Assembly Modules (SAM), of which there are two components:
    - Desktop parts kitting and assembly areas
    - Deskside parts kitting and assembly areas
- Data Center assembly area

[11] CIMTech Corporation. "Factory Flow Software Handbook." Ames, IA. 1995.

- Warehouse
- Order consolidation and shipping area
- System Option Fulfillment area.

The team did not study equipment layout within each of these major manufacturing blocks because of the detailed nature of such an analysis.

In addition, because of the large number of products and options available, the team decided to take a sample of products that were a fair representation of all products that flow through the factory. The volumes of these sample products would be inflated in the model to approximate the total volume of material that moves through the factory.

Naming Conventions

For the final products, the following abbreviations were used:

- Deskside: DS
- Desktop: DT
- Storage Building Block: SBB
- Rack Mount: RM
- Custom Integrated Computing: CIC

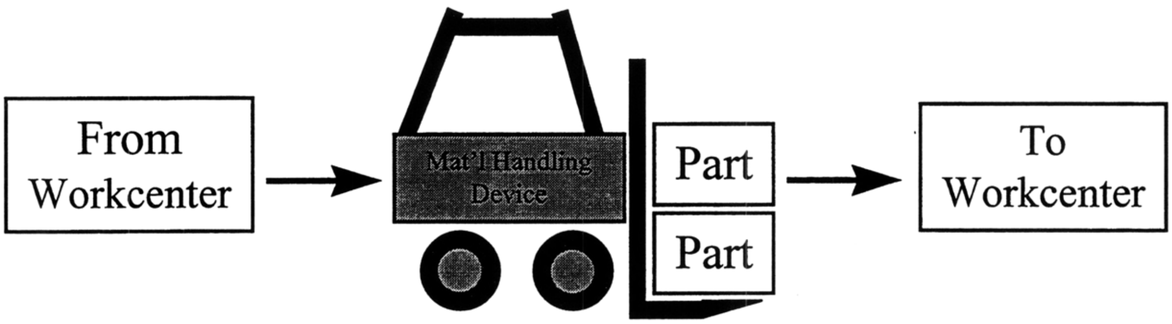
The functional blocks within the factory were named as follows:

- Warehouse dock doors: WHDOCK
- Core B dock doors: BDOCK
- Core C dock doors: CDOCK
- Core D dock doors: DDOCK
- Desktop kitting area: DTK
- Desktop assembly area: DTA
- Deskside kitting area: DSK
- Deskside assembly area: DSA
- CIC assembly area: CIC

Input Data

This phase of the CIMTech flow simulation proved to be one of the most challenging. Because of the large number of products assembled in the factory and the large number of options for each product, there was a vast quantity of data that had to be collected and sorted before any meaningful information could be produced.

The primary method of analysis was to follow a part's flow through the factory, recording total distance and time:



The flow data entered into Factory Flow determines what paths will be drawn and analyzed. There were three data files required for the flow analysis:

Products File	Parts File	Material Handling Equipment File
Product name and production quantity per time unit	Part name, quantity of the part in each finished product unit, from where and to the part is moved, the device named used to move the part, and how many parts are moved at a time	Fixed and variable costs, speed, and effectiveness of the material handling equipment device named in parts file

Products File

As stated above, the team's first major assumption was that a selected cross-section of products could be used in the material flow analysis to approximate the flow of all material through the factory. The products chosen either constituted the majority of the material flow within a certain functional block and/or represented nearly all of the operations that occurred within a given functional area. The team then inflated each product's annual volume to approximate the planned annual volume of all of that family's products. For example, for the Deskside manufacturing area, we chose the "Rawhide" family of products. The Rawhide family of products are the highest volume Deskside product in the Salem facility. They also use the most commonly required options for Deskside products. Thus, the majority of different options and product flows within the Deskside family were captured by approximating all Deskside flows with the Rawhide family of products.

The planned capacity for the Rawhide family is about 20,000 units per year, but the planned capacity for all Deskside products is 48,000 units per year. Thus, in the model, we used a planned capacity of 48,000 Rawhide units per year to approximate the flow of all Deskside units through the factory.

The representative products selected were as follows:

Desktop	Deskside	CIC	Disks	Rackmount	Options
Miata MX3	Rawhide	Turbo	Generic SBB*	Generic Rackmount*	Generic Option*

* Because of the simplicity of operations of these products, each one could be represented by a generic product flow. There are so few deviations from the normal flow that compiling the routings for an actual product and all its (infrequent) options would not significantly affect the material flow intensities through the various functional areas.

An example of the Factory Flow input screen for the products file is as follows:

Product Name	*Quantity per Year*	*Line Color*
RAWHIDE	48,000	1
SHELVES	80,000	2
TURBO	10,000	3
MIATA	80,000	4
RACKMOUNT	2,000	5
DISKS	600,000	6
MX3	20,000	7
SBU_SR_10	23,200	8

Parts File

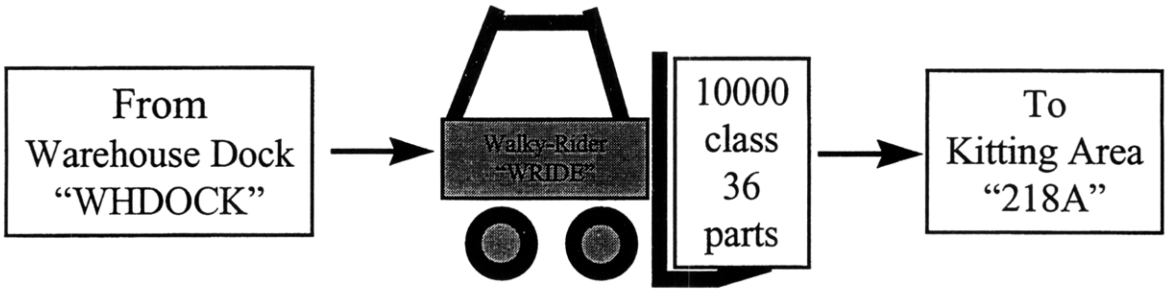
The team's second major assumption of the material flow analysis was that for each product family, specific components can be generically categorized under a single part class. For example, for the routings, we merely used the first two characters from the part number to identify the class of parts to which a particular component belongs.

For example, part #99-5473902-01 is a cardboard box used to package desktop units. Using our assumption, this part simply becomes "99" (packaging material). This was done to simplify the analysis; most parts of the same class have similar characteristics as far as size and quantity per move. By describing all parts of the same class as having the same physical attributes and move quantities, we eliminated the need to describe the attributes of every single part. This was fortunate, as there are literally thousands of parts specified as components in each of the product families.

The parts file requires the routing ("from" and "to") for each component of a product, its "pallet density" (the number of the parts transported in a single move), and the method used to move the part. The following shows the set of assumptions used to describe all of the material flows that occur for the assembly of Storage Building Blocks, or "SBB's." For each class of parts, it documents the route it follows through the factory, what types of material handling equipment are used and how many parts are moved at a time.

Product Family: SBB										
Class	From	Mat. Hand. Method	Pallet Density	To	Mat. Hand. Method	Pallet Density	To	Mat. Hand. Method	Pallet Density	To
36	WHDOCK	WRIDE	10000	218A	WRIDE	10000	218B	WRIDE	10000	SBB
99	DDOCK	WRIDE	250	SBB						
70	WHDOCK	WRIDE	180	218A	WRIDE	180	218B	WRIDE	180	SBB
17	WHDOCK	WRIDE	720	218A	WRIDE	720	218B	WRIDE	720	SBB
90	DDOCK	WRIDE	10000	SBB						
74	WHDOCK	WRIDE	560	218A	WRIDE	560	218B	WRIDE	560	SBB
DEFAULT	WHDOCK	WRIDE	200	218A	WRIDE	200	218B	WRIDE	200	SBB
SBB	SBB	WRIDE	110	183	WRIDE	110	DDOCK			

For example, the first five blocks of the first row describe the following material flow:



Material Handling File

The third file necessary for the model documents the necessary cost and performance characteristics of each type of material handling equipment. In the Salem facility, material is moved primarily by two types of equipment: "walkie-riders," which are motorized pallet jacks upon which operators may stand and ride; and manual pallet jacks, which are pushed or pulled by the operators.

For each material device, the material handling file documents its replacement cost, its hourly fuel, parts, and maintenance costs, the hourly labor costs, the available minutes per year, the load and unload time, the travel speed of the device, the number of devices on-site, and the efficiency of the device. The efficiency of a device shows how often, on average, the device is actually moving material, versus moving without carrying any material. For example, if a hand truck is used to carry a load of boxes from site A to site B and then returns empty to site A for another load, the hand truck is described as being 50% efficient.

An example of the Material Handling file is as follows:

Material Handler Name	*Material Device Type*	*Capital Replacement Cost*	*Hourly Fuel, Parts, & Maint. Costs*	*Hourly Labor Cost*	*Minutes Available/Yr.*	*Load/Unload Time (min)*	*Travel Speed (ft/min)*	*Number on-site*	*Efficiency*
WRIDE	LIFT_TRUCK	$3,000	$1.00	$15.00	230,400	1	250	15	70%
HANDT	HAND_TRUCK	$100	-	$15.00	230,400	1	50	21	50%
CONV	CONVEYOR	$25,000	$5.00	$0.00	230,400	-	0	1	
CART	HAND_TRUCK	$100	-	$15.00	230,400	1	50	12	50%

AutoCAD Plant Drawing

Once all three Factory Flow files were created, the team created an AutoCAD drawing of the original (existing) and proposed factory layouts and defined all of the functional areas and aisles for material movement throughout the factory.

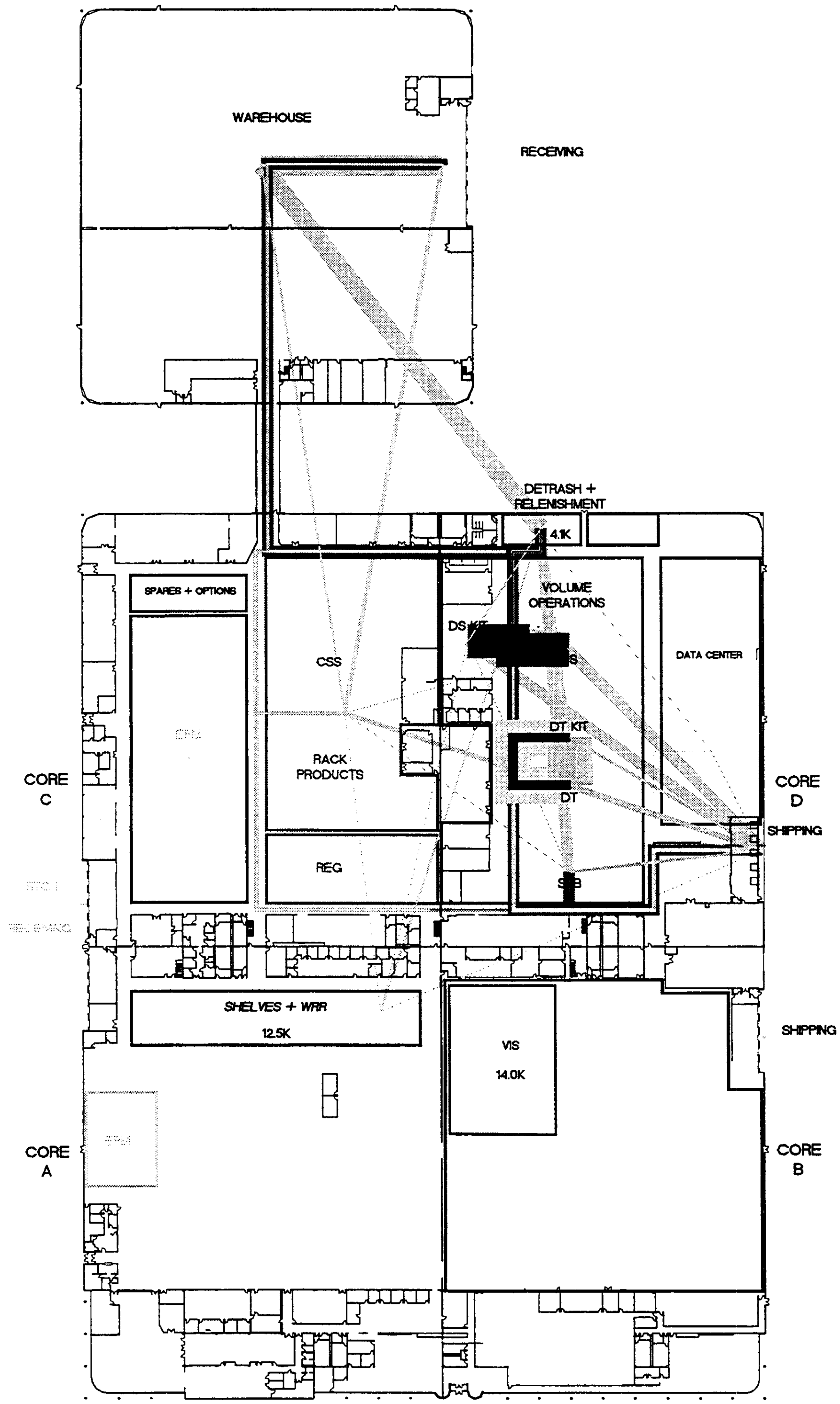
Integration of Drawing and Data

The team then ran the Factory Flow software for the original factory and the proposed layout. There were several results the team sought to ensure that the recommended layout was appropriate:

- The widest lines (those lines that represented the greatest amount of material flow intensity) should be short. Wide and long lines are indicative of a sub-optimal layout, as a significant amount of material must move a long distance through the facility, adding time and expense to the material flow process.
- The material flow through the facility should be as simple as possible, and as often as possible, flows should move in one direction along any given path.

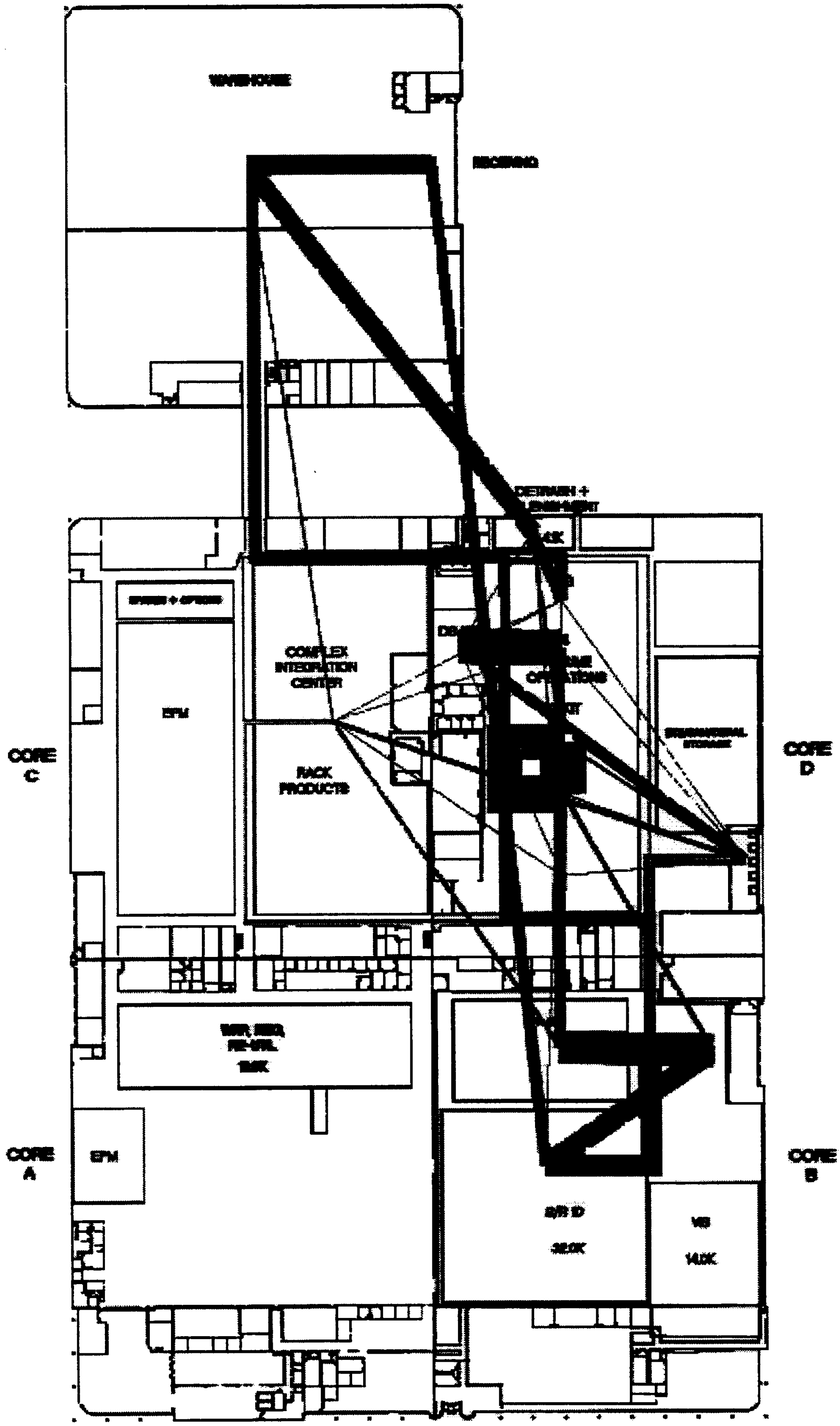
The results were as follows:

Existing Layout



JUNE 1997

Proposed Layout



Interpretations:

- There was little difference in the Core D material flows between the "Existing Layout" and the "Proposed Layout." The main difference was the moving of shipping activity from the Core D dock doors to the Core B dock doors in the proposed layout. In both cases, a significant amount of material is received in the Core D dock doors.
- The Order Consolidation and Systems Options Fulfillment businesses were moved to Core B from Dascomb Road (external facility) under the proposed layout scenario. There was a high flow of material in this area (note the very wide lines in Core B), but since all shipping activity takes place through the Core B dock doors, these lines are short.
- There is a long, fairly wide line from the warehouse to Core B because of the number of options received at the warehouse and moved directly to Core B. This line could be alleviated by receiving all options through the Core D dock doors.
- There is also a fairly wide and long line from the warehouse to the top of Core D. This line could be reduced by receiving a number of high-volume components, such as disks and shelves, through the Core D dock doors, which are closer to their point of use.
- It is nearly impossible to tell which direction material is flowing from these diagrams, so the team created two more diagrams that qualitatively illustrate the difference between the existing layout and the proposed layout. These diagrams are included in the main text of the document (Chapter 5).

Reports for Analysis

The team then created a spreadsheet to analyze the difference in material flow between the existing, June 1997 layout and the proposed layout. In order to make a fair comparison between the two layouts, we compared only the distances products travel between their arrival into the factory and up to and including their assembly. All travel within the factory after assembly is ignored. In the June 1997 layout, the material would have left the facility at this point, while in the proposed layout, the material would have gone on to Core B for consolidation with options and ultimately, for shipping.

An example of the data used in our analysis is as follows:

Product name: TURBO

	Distance
Between WHDOCK and 218A	1,068,117
Between 218A and CIC	3,775,546
Between DDOCK and CIC	11,069,650
Between CIC and WHDOCK	10,386,585
Total	26,299,898

The above report tracks the total annual distance parts travel between various locations on the factory floor for a particular family of products. The reports for the June 1997 layout are then compared to the proposed layout. The analysis revealed that by delivering enclosures through Core C doors and disks and shelves through Core D doors, the annual material flow intensity in the factory could be reduced by **20%**.

Analysis of Reports & Recommendation

The team's assessment was that the recommended layout would allow for a superior flow of material through the facility, assuming the following actions were taken:

1. All options should be received through the Core D dock doors.
2. High volume components, such as disks, shelves, and enclosures should be received in to the factory through the dock doors nearest their point of use.
3. All shipping activity should take place through Core B dock doors.

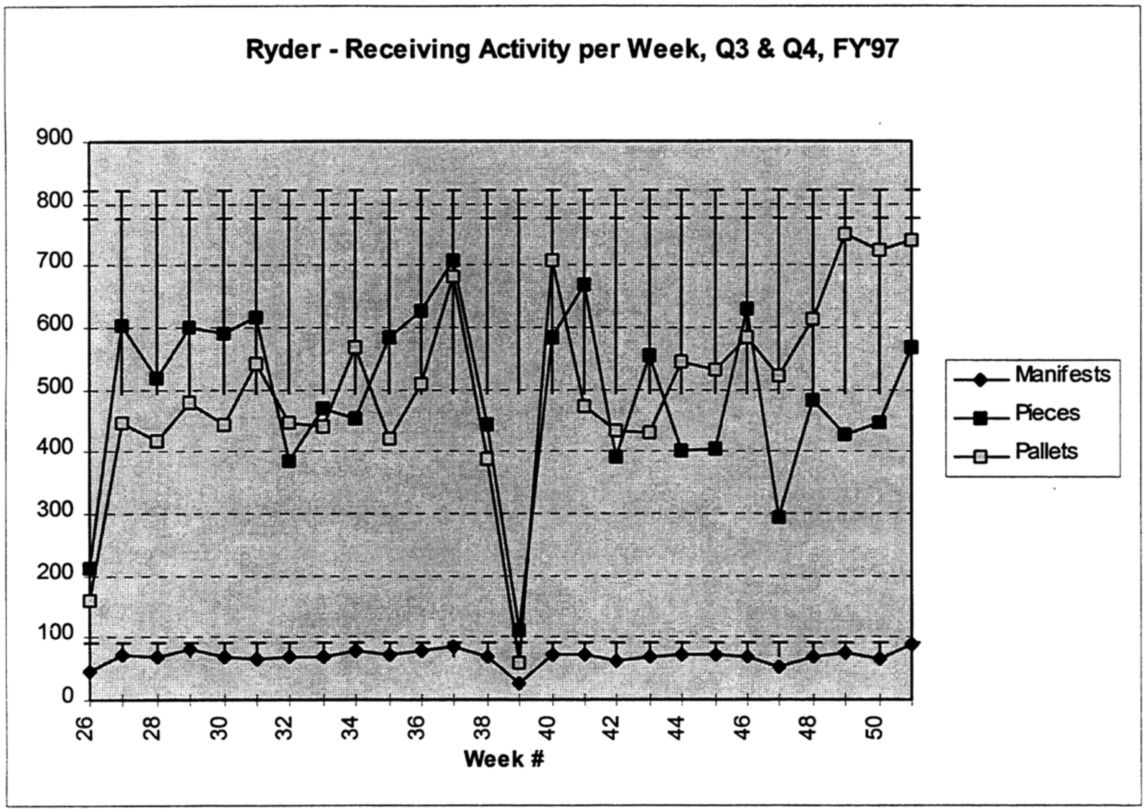
Appendix B - Inbound and Outbound Capacity Analysis

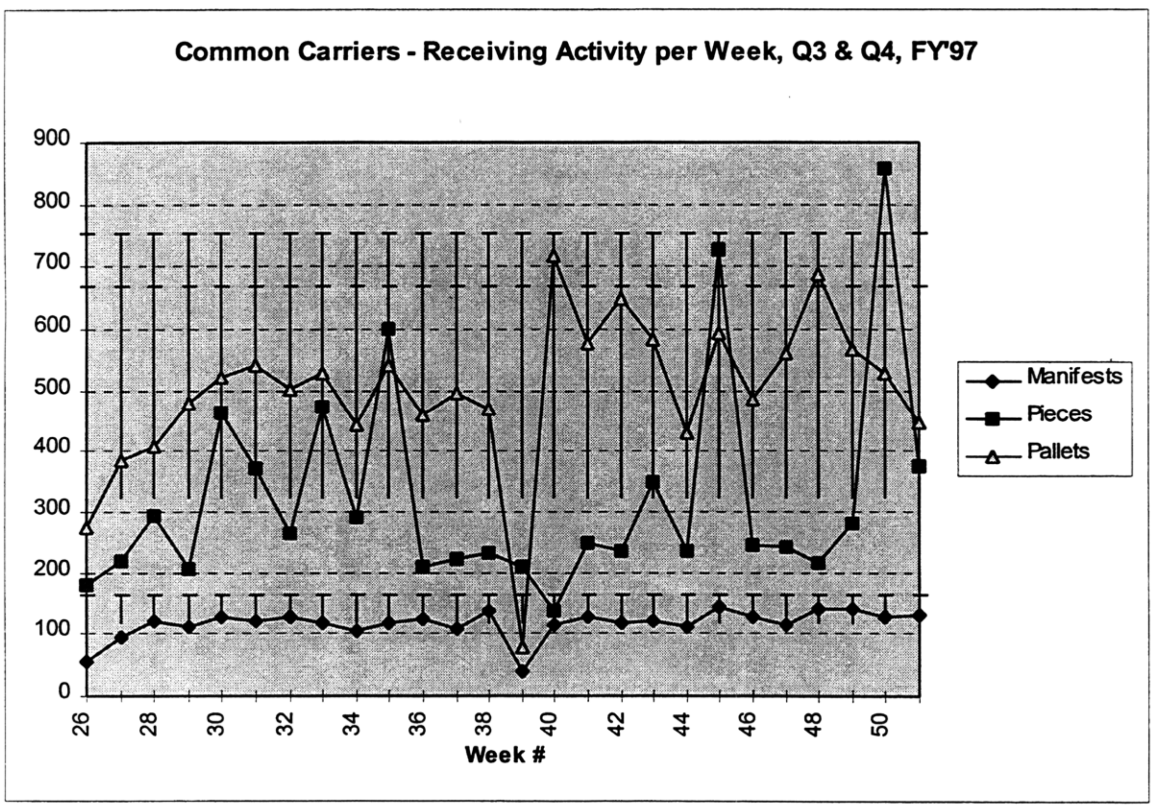
Inbound Model - Receiving Volume Analysis

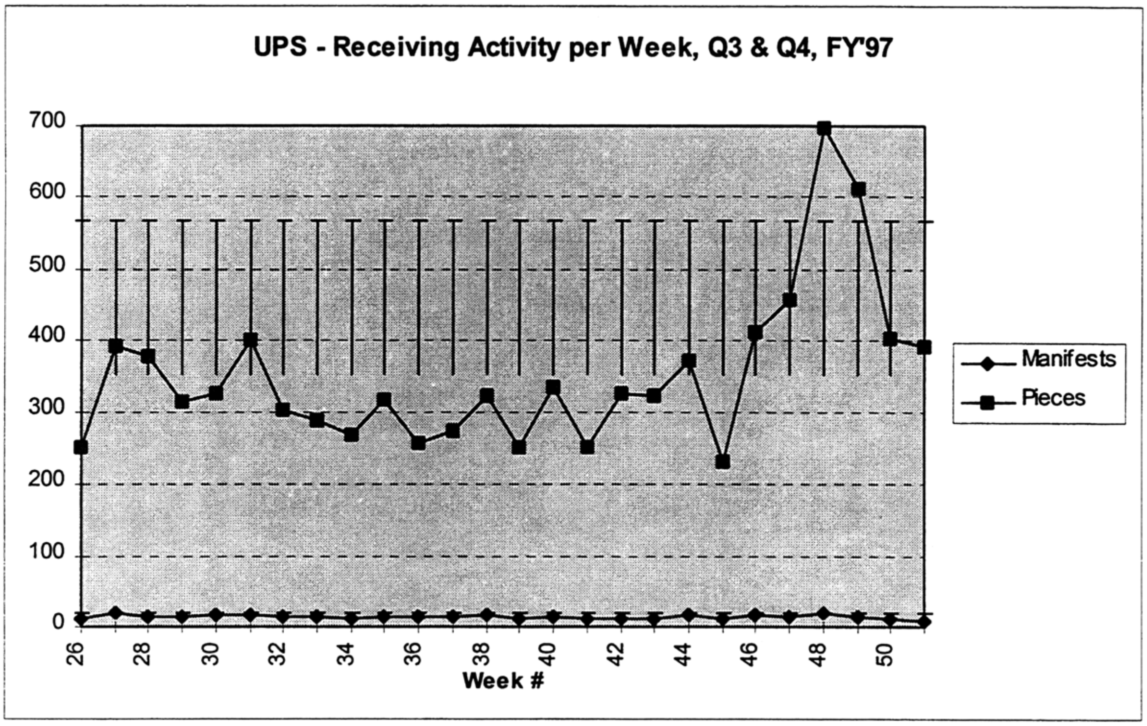
By looking at the shipping data segmented by different types of carriers, the team hoped to understand how much of the receiving activity involved large 18-wheel trucks loaded with pallets versus smaller delivery vans loaded with only boxes. If there were a significant volume of smaller truck activity, then the selected model would have to be reevaluated since the model is based on the assumption that most of the activity in the warehouse involves18-wheel trucks. Typically, 18-wheel trucks spend more time at the receiving docks than do the smaller trucks carrying only boxes.

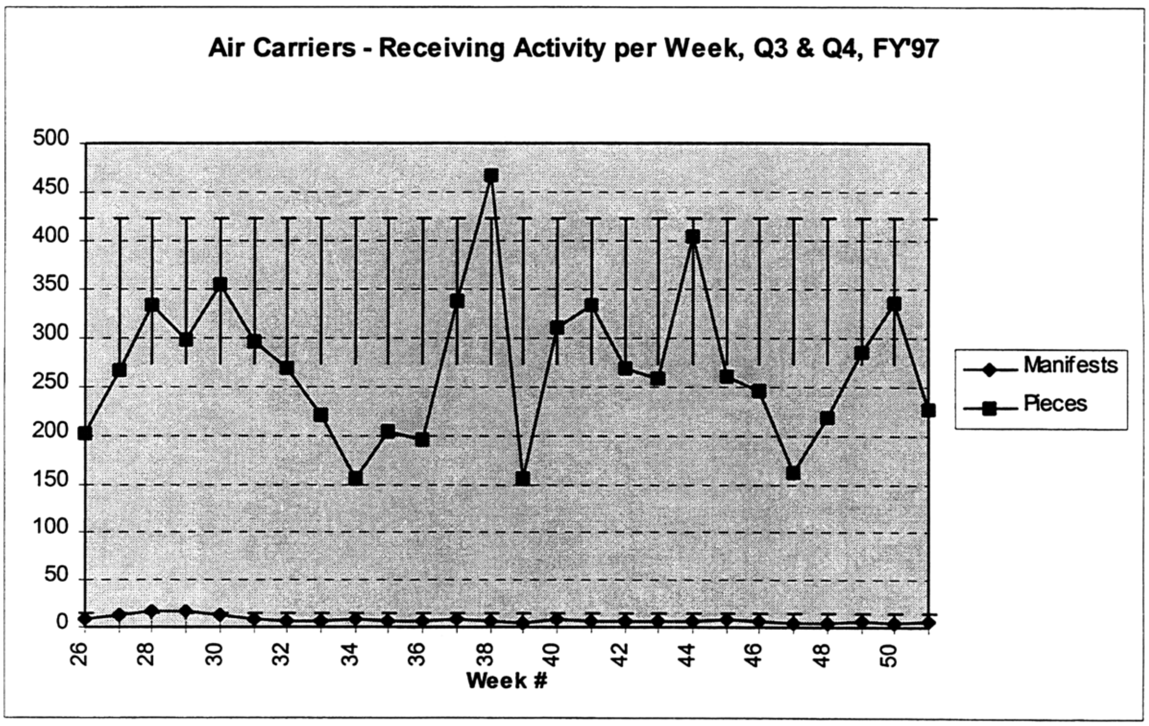
There were four different types of carriers segmented in the data: Common Carriers, Ryder, Air Carriers, and UPS. Common Carriers and Ryder were similar because both consistently used large trucks loaded with both pallets and pieces. Air Carriers and UPS were similar because both consistently used smaller trucks and carried only packages.

For each type of carrier, the team plotted the number of manifests (directly related to the number of trucks), the number of pieces, and the number of pallets received per week. For each plot, we added the y-axis error bar of the mean plus 2 times standard deviation. Any plot with a point above this error bar could be cause for further scrutiny. The shipping histories for Q3 and Q4 FY'97 were as follows:


Ryder - Receiving Activity per Week, Q3 & Q4, FY'97
900
800
700
600
500
400
300
200
100
0
26
28
30
32
34
36
38
40
42
44
46
48
50
Week #
Manifests
Pieces
Pallets


Common Carriers - Receiving Activity per Week, Q3 & Q4, FY'97
900
800
700
600
500
400
300
200
100
0
26
28
30
32
34
36
38
40
42
44
46
48
50
Week #
Manifests
Pieces
Pallets



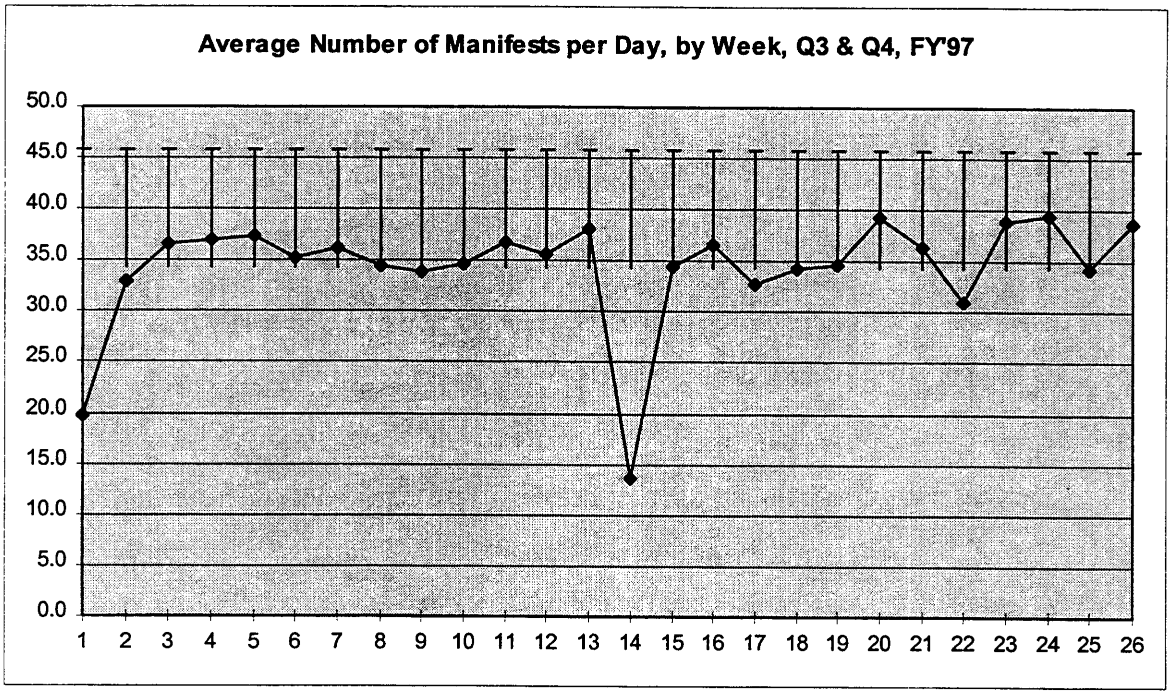


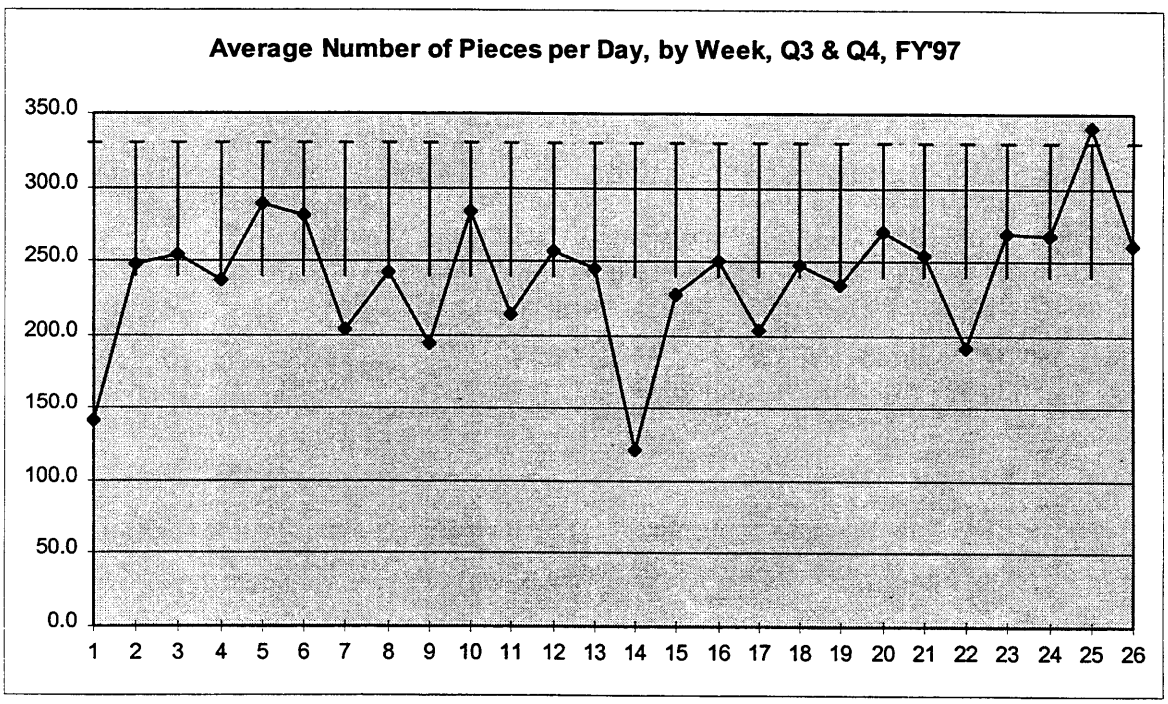
There were several conclusions that can be drawn from these graphs:

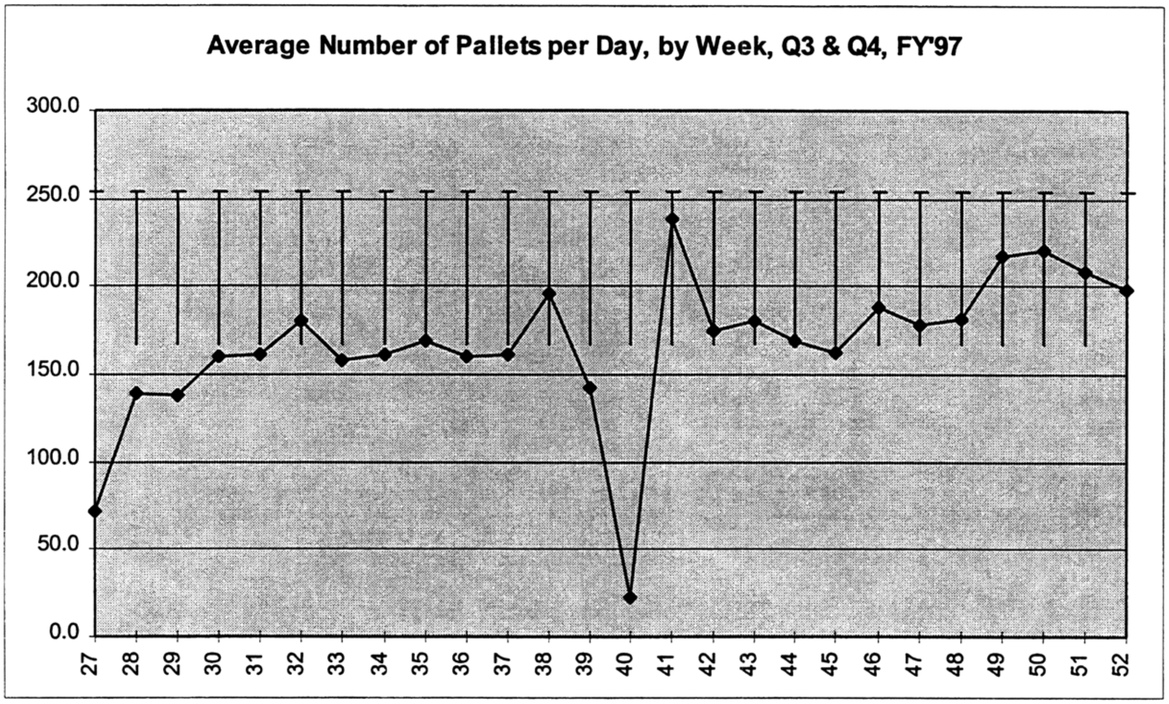
- Ryder and Common Carrier have a combined average of 184 manifests/week. UPS and Air Carriers have a combined average of 22 manifests per week. Thus, the small truck receiving activity in the warehouse represents only about 10% of the total trucking activity at the warehouse. The team concluded its assumption – that all trucking activity in the warehouse area had the characteristics of the large, 18-wheel trucks – was valid.

- During the first week of each fiscal quarter (weeks 26 and 39), there was a significant decrease in activity.
- The number of pallets Ryder delivers per week has an upward trend through the quarter, while there does not seem to be any trend on the number of pieces delivered. However, at no point during this sampled time period does any of the Ryder activities exceed the mean plus 2 times standard deviation limit.
- The number of pieces the Common Carriers deliver per week has an upward trend through the quarter, although there did not seem to be any trend as to the number of pallets delivered. There is one point in Q4 where the number of pieces delivered exceeds the mean plus 2 times standard deviation limit.
- There is a significant spike in activity for UPS during the end of Q4, and for two weeks, the receiving activity exceeds the mean plus 2 times standard deviation limit. This is due to the factory expediting small parts to fulfill orders before the end of the quarter.
- There is one point during the end of Q3 that receiving activity for the Air Carriers exceeds the mean plus 2 times standard deviation limit.
- By adding one door to the total door requirement calculation and dedicating it for last-minute "emergency" needs, such as FedEx (an air carrier) and UPS, bottlenecks could be prevented from occurring when the end-of-quarter volume increase occurs.

The next issue that needed to be addressed was the receiving volume skew by week. Do any of the trends noted above by carrier actually affect the total receiving volume? Or is one carrier's increase offset by another's decrease? To answer these questions, the team plotted each week's average number of manifests, pallets, and pieces delivered per day. Again, the team added the mean plus 2 times standard deviation y-axis error bars to each graph. The results are shown below:


Average Number of Manifests per Day, by Week, Q3 & Q4, FY'97
50.0
45.0
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26


Average Number of Pieces per Day, by Week, Q3 & Q4, FY'97
350.0
300.0
250.0
200.0
150.0
100.0
50.0
0.0
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26



The team drew the following conclusions from the above graphs:

- Because the number of manifests is directly proportional to the number of trucks received each day, it can be assumed that the daily volume of trucks remains relatively constant.
- There is one point in the average number of pieces received per day that exceeds the mean plus 2 times standard deviation upper limit. This occurrence reinforced the recommendation that one door be added to the total door requirement to accommodate last-minute deliveries of small packages.
- The mean plus 2 times standard deviation upper limit should be sufficient for calculating the required number of doors.

Thus, by using the mean plus 2 times standard deviation method and adding one to the total, the required number of dock doors for receiving in the warehouse came to **six (6)**.

A sample of the data and the assumption input area of the model is shown below:

Sampled Analysis - by day of week and by week

Week	Number of Manifests	Number of Trucks	Number of Pieces	Number of Pallets	Total Dock Minutes	Required # Doors
27						
Monday	23	14.4	156	49	622	1.1
Tuesday	19	11.9	130	46	535	0.9
Wednesday	0	0.0	0	0	0	0.0
Thursday	32	20.0	260	138	1169	2.0
Friday	37	23.1	261	195	1431	2.5
Saturday	7	4.4	39	4	140	0.2
52						
Monday	50	31.3	288	278	1909	3.3
Tuesday	40	25.0	271	187	1448	2.5
Wednesday	48	30.0	353	304	2058	3.6
Thursday	46	28.8	258	262	1770	3.1
Friday	38	23.8	294	139	1281	2.2
Saturday	10	6.3	98	19	299	0.5
		3349.4	37364	26022		
Mean	34.4	21.5	239.5	166.8	1274.4	2.2
Median	39.0	24.4	258.0	180.5	1433.6	2.5
Std Dev.	15.5	9.7	128.8	92.7	610.2	1.1
Maximum	68.0	42.5	787.0	390.0	2622.9	4.6

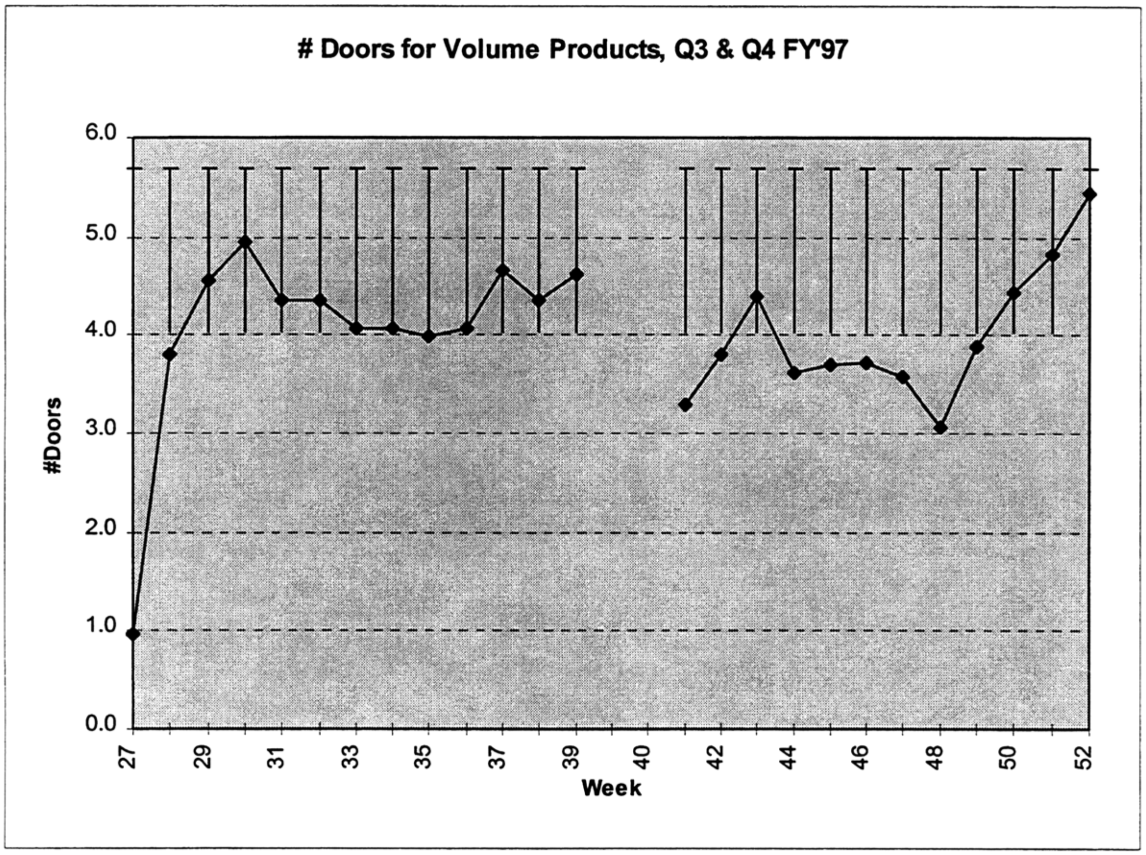
Manifests per Truck	Manifests	Trucks
	Sampled Data 9/2 - 9/5	
Tues	35	25
Wed	35	23
Thurs	40	22
Fri	34	20
Total	144	90
Manifests per Truck	1.6	

Assumptions on Standard Deliveries	Sampled Data: Pull-in, Pull-Out	Sampled Data: Time/Piece (min.)	Sampled Data: Time/Pallet (min.)	Management Factor	Available Minutes/Day per Door	Dock Door Untilization	Annual Revenue Growth
	15	1	3	1.2	960	60%	15%

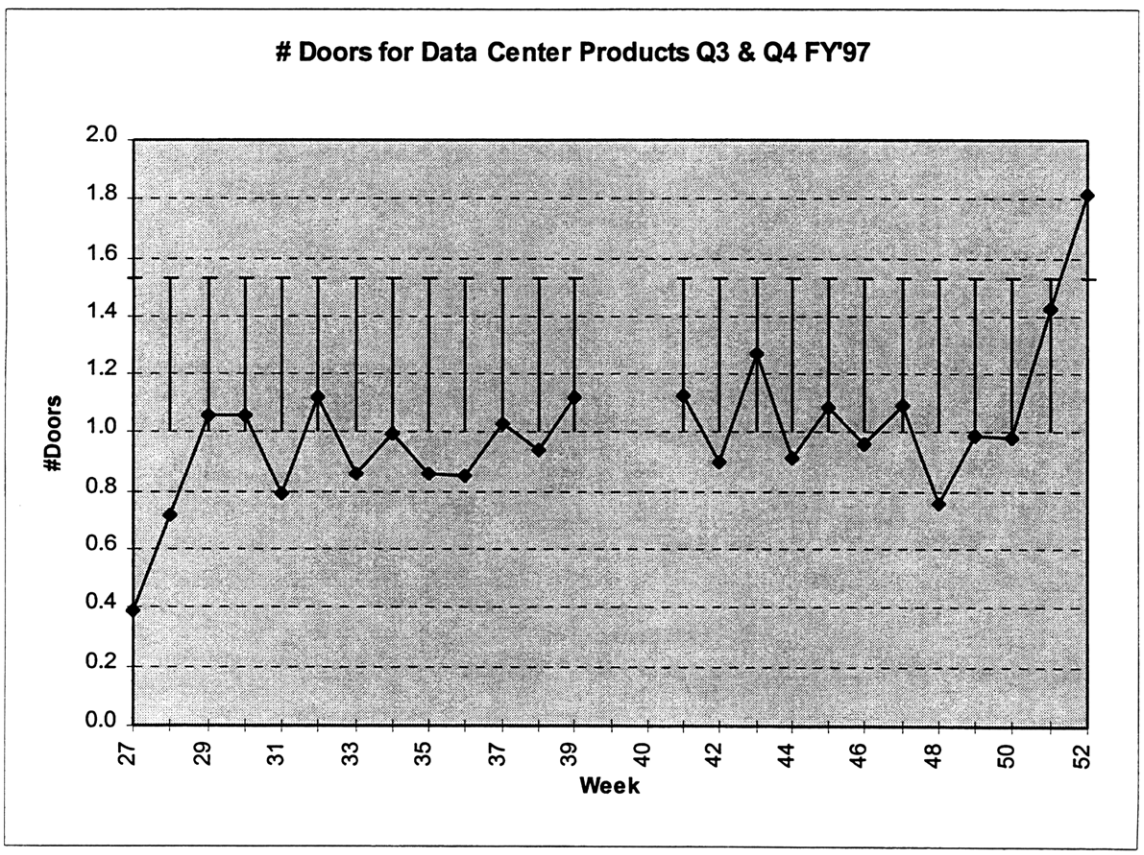
WAREHOUSE	**Number of Non-JIT Doors Required FY'97** 4.09 **5.00** = Mean + 2 * Std. Deviation Plus one Door for Quick deliveries, UPS, etc. **6.00**

Outbound Model - Shipping Volume Analysis

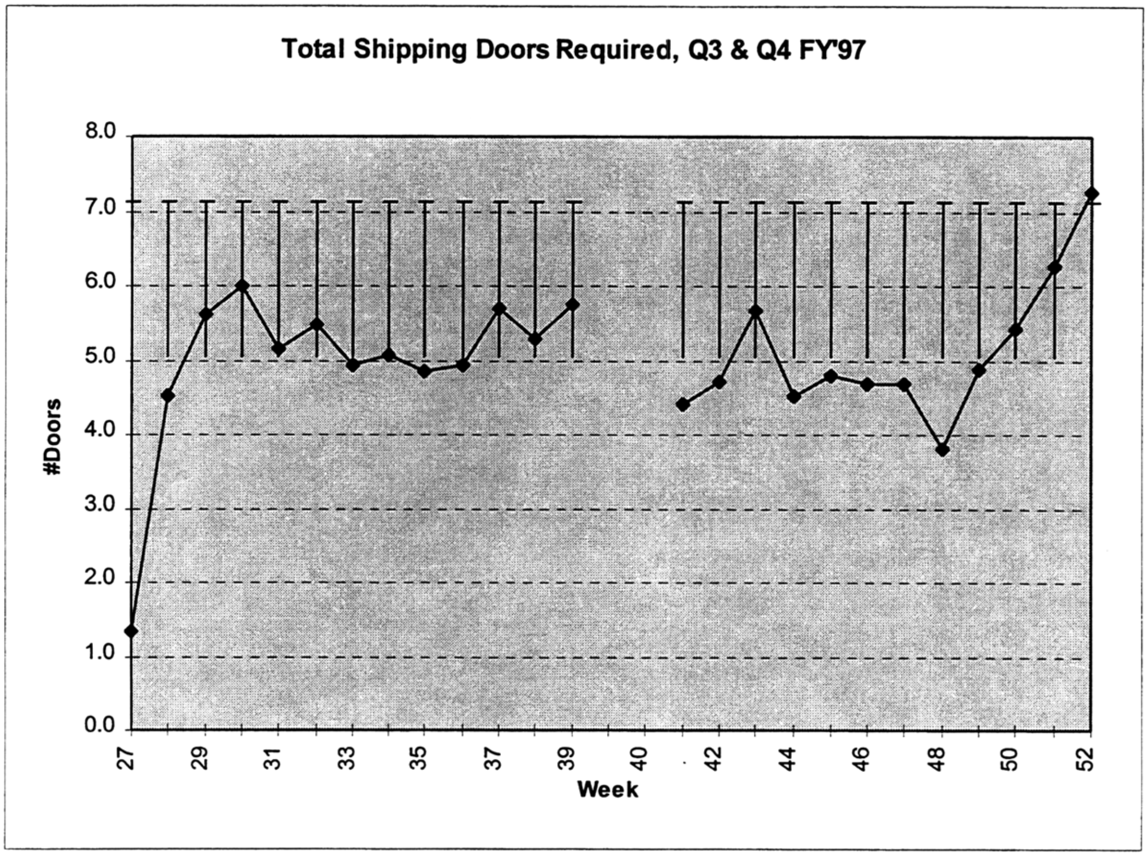
By plotting the historical shipping activity (shown below), the team sought to understand the nature of shipping behavior and to verify that using the mean plus 2 times standard deviation was an adequate method for calculating the required number of doors.



Doors for Volume Products, Q3 & Q4 FY'97
6.0
5.0
4.0
3.0
2.0
1.0
0.0
#Doors
27
29
31
33
35
37
39
40
42
44
46
48
50
52
Week



Doors for Data Center Products Q3 & Q4 FY'97
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
#Doors
27
29
31
33
35
37
39
40
42
44
46
48
50
52
Week



There were a number of conclusions that can be drawn from these graphs:

- Having a total of eight (8) doors should be more than enough to handle even the periods of highest volume. The mean plus 2 times standard deviation and then rounding the result up to the next whole number resulted in a total of eight (8) doors necessary for shipping requirements.
- There was a significant upwards trend in shipment volume during the end of Q4 FY'97.
- The high-volume products represented 80% of the shipping activity, while the lower-volume CIC products represented only 20% of the shipping activity.

A sample of the data and the assumption input area of the model is shown below:

Assumptions	
Number of Volume Products per Pallet *3*	Available Minutes/Day *960*
Number of CIC Products per Pallet *1*	Management Factor *1.2*
Number of Pallets per Truck *20*	Door Utilization *60%*
Average Truck Time at Door (min) *50*	

VOL Products (DT/DS)

Total Weekly Volumes

Week	*Cust.*	*Intl.*	*Inter.*	*Intra.*	*SBA's*	*Total*	#Trucks	#Doors	
27	121	111	297	9	18	556	*9.3*	*1.0*	
28	874	137	923	201	51	2186	*36.4*	*3.8*	
29	1097	254	983	259	32	2625	*43.8*	*4.6*	
50	1051	287	604	615	1	2558	*42.6*	*4.4*	
51	1325	241	563	643	15	2787	*46.5*	*4.8*	
52	1936	206	593	379	20	3134	*52.2*	*5.4*	
								4.0	mean
								0.84	std dev

Data Center Products

Total Weekly Volumes

Week	*Cust.*	*Intl.*	*Inter.*	*Intra.*	*D. M.*	*Total*	#Trucks	#Doors	
27	115	44	66	0	0	225	*3.8*	*0.4*	
28	262	51	93	5	0	411	*6.9*	*0.7*	
29	275	75	117	10	134	611	*10.2*	*1.1*	
50	267	56	101	18	124	566	*9.4*	*1.0*	
51	391	122	149	39	121	822	*13.7*	*1.4*	
52	697	63	115	46	126	1047	*17.5*	*1.8*	
								1.0	mean
								0.26	std dev

Grand Total

Week	*Grand Total*	*#Doors*
27	781	1.4
28	2597	4.5
29	3236	5.6
50	3124	5.4
51	3609	6.3
52	4181	7.3
		5.0 mean
		1.0 std dev

Total Number of Doors Required
8.0 *roundup(mean + 2*std dev)*

Appendix C - Description of Reengineering Elements

Following is a summary of the operational advantages, customer advantages, financial implications, and assumptions of each element in the reengineering of the Salem facility:

Move Tenants out of Salem

- Operational Advantage: More space available for manufacturing, consolidation, and distribution

- Financial Implications:

Capital:	Computer Network installation	$330K
Capital:	Fit-up alt. site for displaced tenants	$1,200K
Expense:	De-fit Core B	$557K
Expense:	Fit-up Core B	$200K
Expense:	Asset write-offs	$1,450K
Expense:	Move tenants to new location	$160K

- Dependencies: Space elsewhere for tenants

Consolidate Warranty, Repair, Reutilization (WRR) in Core A

- Operational Advantage: Consolidation of similar tasks offers economies of scale
  More effective/flexible utilization of labor

- Financial Implications: Expense: Consolidation and Move $140K

Consolidate Storage Shelf Build to Core A

- Operational Advantage: Consolidation of similar tasks offers economies of scale
  More effective/flexible utilization of labor

- Customer Advantage: Improved predictability & responsiveness

- Financial Implications: Expense: Consolidation and Move $223K

Move SR183 from Dascomb Road to Salem

Currently, all finished products are shipped to another local building, "Dascomb Road" (DAS), approximately a twenty minute drive from the Salem facility. DAS has, among other functions, the responsibility to consolidate all customer orders manufactured at the Salem facility and ship the orders to the customer. One to three days are added to the order cycle time by sending products to DAS, consolidating them, and shipping them to the customer. Transporting material from Salem to DAS adds to the cost of the manufacturing and shipping process due to additional trucking costs as well as additional administrative work that needs to be done to track the material between the two sites. The management of Salem hopes to eliminate these additional days on the order cycle time process and additional costs by bringing all the order consolidation and shipping responsibilities back to Salem.

- Operational Advantage: Vertical integration facilitates better inventory control
  Increased visibility and proximity to factory
  Improves predictability
  Reduces order cycle time

- Customer Advantage: 1-3 day cycle time improvement
  Improved predictability and responsiveness

- Financial Implications: Expense: De-fit, racking, fit-up, etc. $76K
  Savings: Labor $100K
  Savings: Freight $170K
  Savings: DAS occupancy and pallet charge $130K

Move Stockroom 10 (Systems Options Only) to Core B

Dascomb Road is also responsible for receiving and shipping all "non-embedded" options for all orders placed through the Salem facility. Non-embedded options are parts and components that a customer may order for a system but are not installed inside that system. For example, a customer may order a Deskside server with a number of hard drives installed, but may also wish to have an additional, external hard drive shipped with the order. This additional external hard drive would be classified as a "non-embedded option."

The management of Salem also hopes to store most of the non-embedded options in the Salem facility to allow an order to be shipped complete directly to the customer, thereby bypassing DAS entirely. This change should reduce the total order cycle time, which should allow for greater order predictability.

• Operational Advantage:	Vertical integration	
	Increased visibility and proximity to factory	
	Improves predictability	
	Reduces order cycle time	
• Customer Advantage:	1-3 day cycle time improvement	
	Improved predictability and responsiveness	
• Financial Implications:	Capital: Dock doors (5 added)	$460K
	Capital: Core B fit-up	$300K
	Expense: 15 new people in Salem	$750K
	Savings: In-transit merge /DAS	$1,412K
	Savings: Short-ship/Mis-ship Improvements	$120K

Implement SAM for all High-Volume Products

An effort to implement a new type of manufacturing cell for the high volume, SBU products is underway. The Salem Assembly Module (SAM) brings a larger amount of inventory to the floor and directly into a manufacturing cell optimized for quick changeover. Previously, an individual operator at a workbench would assemble a high volume SBU product. The operator would have a "kitted" bin of parts necessary for the completion of the order brought to him/her from a parts kitting area.

Under the new SAM system, all components necessary for assembly of a product are stored at the manufacturing cell. Also, the SAM cell is flexible so that products can be assembled by an individual operator or in a progressive line assembly process.

The SAM cells bring increased visibility to the amount of material being used and should help to prevent many of the stock-outs. There are expected gains in operator efficiency, which increase the capacity of the plant, and there are significant material handling savings, due to the elimination of kitting parts in a bin in a separate area of the facility. Finally, there is a one-time inventory saving due to the improved material control of the SAM cell.

• Operational Advantage:	Improved inventory control	
	Fewer stock-outs through redundant Kan-Ban	
	25% increase in manufacturing capacity	
	60% fewer kitters required	
	More manufacturing flexibility	
• Customer Advantage:	Cycle time reduction	
	Improved predictability	
• Financial Implications:	Capital: Equipment	$925K
	Expense: Fit-up	$350K
	Expense: IS contract personnel	$60K
	Expense: NIO implementation team	$322
	Savings: Inventory carrying costs	$1,846K
	Savings: Inventory cycle time	$431K
	Savings: SAM headcount	$1,504K

Total Expense, Capital, and Savings Summary

Reengineering Program Expenses		
Consolidate Manufacturing. Processes		$390K
Implement Salem Assembly Module		$732 K
Move Tenants		$160 K
Asset Writeoff for Tenant Move		$1,450 K
Defit Core B		$557 K
Refit Core B		$200 K
Move Shipping from DAS to NIO		$76 K
Distribute Options from Salem (15 H/C)		$750 K
Sub-Total		$4,315 K

Reengineering Capital Requirements		
Capital - Dock Doors		$460 K:
• *Exterior construction*	*$200 K*	
• *Interior construction*	*$150 K*	
• *Door Equipment and hardware*	*$110 K*	
Capital - Core B		$630 K:
• *Core B fit-up*	*$300 K*	
• *Computer network installation*	*$330 K*	
Capital - AKO Fit-up		$1,200 K:
• *Dock Door & Exterior Constr.*	*$320 K*	
• *Lab Fit-Up*	*$630 K*	
• *Network installation*	*$250 K*	
Salem Assembly Module Equipment		$925 K
Total		$3,215 K

Reengineering Savings (Year 0)	
Reduced Labor - SAM/Shipping (50 H/C)	$1,604 K
Freight Savings for Shipping Move	$170 K
DAS W/H & PPS Options Savings	$472 K
In-transit Merge Minimization-DEC	$168 K
In-transit Merge Minimization-Customer	$672 K
Short-ship/Mis-ship Improvements	$120 K
Inventory/Cycle Time Reduction for SAM	$2,277 K
Total Savings	$5,483 K

Following are the Net Present Value models created for the five different iterations. The lower-right hand corner in each spreadsheet shows the cumulative Net Present Value for each iteration.

Americas Manufacturing & Distribution
Salem Plant Reengineering Program
Savings/Cost Analysis - $K

Iteration 1	Total Digital Relocate the ESE Group to AKO and Relocate the NSTG Group to ZKO. Move third tenant Move Shipping and Options to Core B

Reengineering Program Savings:		***Year 0***	***Year 1***	***Year 2***	***Year 3***	***Year 4***	***Year 5***
Reduced Labor - SAM/Shipping (50 H/C)		1604	1604	1604	1604	1604	1604
Freight Savings for Shipping Move		170	170	170	170	170	170
DAS Warehouse Savings for Shipping		0	0	0	0	0	0
DAS W/H & PPS Options Savings		472	472	472	472	472	472
Intransit Merge Minimization-DEC		168	168	168	168	168	168
Intransit Merge Minimization-Customer		672	672	672	672	672	672
Shortship/Misship Improvements		120	120	120	120	120	120
Inventory/Cycle Time Reduction for SAM		2277	431	431	431	431	431
Total Savings		5483	3637	3637	3637	3637	3637
Reengineering Program Costs:							
Consolidate Mfg. Processes		390	0	0	0	0	0
Implement Salem Assembly Module		732	0	0	0	0	0
Move Tenants		160	0	0	0	0	0
Asset Writeoff for Tenant Move		1450	0	0	0	0	0
Defit Core B		557	0	0	0	0	0
Refit Core B		200	0	0	0	0	0
Move Shipping from DAS to NIO		76	0	0	0	0	0
Distribute Options from Salem (15 H/C)		750	750	750	750	750	750
Sub-Total		4315	750	750	750	750	750
Reengineering Capital Requirements:	**$K**						
Capital Depreciation-Dock Doors	460	44	42	39	37	35	33
Capital Depreciation-SAM	925	206	180	154	128	103	77
Capital Depreciation-Core B	630	140	123	105	88	70	53
Capital Depreciation-AKO	1200	267	233	200	167	133	100
Sub-Total	3215	656	577	499	420	341	262
Other Program Expenses:							
Loss of Tenant Rent		0	0	0	0	0	0
Total Cost		4971	1327	1249	1170	1091	1012
Net Program Savings/(Loss)		512	2310	2388	2467	2546	2625
Cumulative Program Savings/(Loss)		512	2822	5210	7677	10223	12848

Cash Flow Analysis:						
Add Back Depreciation	656	577	499	420	341	262
Add Back Asset Writeoff	1450	0	0	0	0	0
Less Capital Outlay	3215	0	0	0	0	0
Equals Cash Flow - Annual	(597)	2887	2887	2887	2887	2887
Equals Cash Flow Cumulative		2290	5177	8064	10951	13838
Net Present Value @20% - Annual	(597)	2405	2004	1672	1392	1161
Net Present Value @20% - Cumulative		1808	3811	5483	6875	8035
Payback Period - Months		14				

Americas Manufacturing & Distribution
Salem Plant Reengineering Program
Savings/Cost Analysis - $K

Iteration 2

Total Digital
New Building Addition
Compress Tenants in Core B/Move Shipping & Options to Core A/B
Move Plant Admin in Core A to New Building

		Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Reengineering Program Savings:							
Reduced Labor - SAM/Shipping (50 H/C)		1604	1604	1604	1604	1604	1604
Freight Savings for Shipping Move		170	170	170	170	170	170
DAS Warehouse Savings for Shipping		0	0	0	0	0	0
DAS W/H & PPS Options Savings		472	472	472	472	472	472
Intransit Merge Minimization-DEC		168	168	168	168	168	168
Intransit Merge Minimization-Customer		672	672	672	672	672	672
Shortship/Misship Improvements		120	120	120	120	120	120
Inventory/Cycle Time Reduction for SAM		2277	431	431	431	431	431
Total Savings		5483	3637	3637	3637	3637	3637
Reengineering Program Costs:							
Consolidate Mfg. Processes		390	0	0	0	0	0
Implement Salem Assembly Module		732	0	0	0	0	0
Move Tenants		100	0	0	0	0	0
Asset Writeoff for Tenant Move		500	0	0	0	0	0
Defit Core B		200	0	0	0	0	0
Refit Core B		200	0	0	0	0	0
Move Shipping from DAS to NIO		76	0	0	0	0	0
Distribute Options from Salem (15 H/C)		750	750	750	750	750	750
Sub-Total		2948	750	750	750	750	750
Reengineering Capital Requirements:	$K						
Capital Depreciation-Dock Doors	460	44	42	39	37	35	33
Capital Depreciation-SAM	925	206	180	154	128	103	77
Capital Depreciation-Core B	850	189	165	142	118	94	71
Capital Depreciation-New Building	2800	267	253	240	227	213	200
Sub-Total	5035	705	640	575	510	446	381
Other Program Expenses:							
Incremental Operating Cost - New Building		350	350	350	350	350	350
Total Cost		4003	1740	1675	1610	1546	1481
Net Program Savings/(Loss)		1480	1897	1962	2027	2091	2156
Cumulative Program Savings/(Loss)		1480	3377	5339	7365	9457	11613
Cash Flow Analysis:							
Add Back Depreciation		705	640	575	510	446	381
Add Back Asset Writeoff		500	0	0	0	0	0
Less Capital Outlay		5035	0	0	0	0	0
Equals Cash Flow - Annual		(2350)	2537	2537	2537	2537	2537
Equals Cash Flow Cumulative			187	2724	5261	7798	10335
Net Present Value @20% - Annual		(2350)	2113	1761	1469	1223	1020
Net Present Value @20% - Cumulative			(237)	1524	2993	4216	5236
Payback Period - Months			23				

Americas Manufacturing & Distribution
Salem Plant Reengineering Program
Savings/Cost Analysis - $K

Iteration 3

Total Digital
Compress Tenants
Move Shipping/Keep Options in Das
100% SAM Implementation

	$K	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Reengineering Program Savings:							
Reduced Labor - SAM/Shipping (50 H/C)		1604	1604	1604	1604	1604	1604
Freight Savings for Shipping Move		170	170	170	170	170	170
DAS Warehouse Savings for Shipping		0	0	0	0	0	0
DAS W/H & PPS Options Savings		0	0	0	0	0	0
Intransit Merge Minimization-DEC		0	0	0	0	0	0
Intransit Merge Minimization-Customer		0	0	0	0	0	0
Shortship/Misship Improvements		120	120	120	120	120	120
Inventory/Cycle Time Reduction for SAM		2277	431	431	431	431	431
Total Savings		4171	2325	2325	2325	2325	2325
Reengineering Program Costs:							
Consolidate Mfg. Processes		390	0	0	0	0	0
Implement Salem Assembly Module		732	0	0	0	0	0
Compress Tenants		100	0	0	0	0	0
Asset Writeoff for Tenant Move		500	0	0	0	0	0
Defit Core B		0	0	0	0	0	0
Refit Core B		0	0	0	0	0	0
Move Shipping from DAS to NIO		76	0	0	0	0	0
Distribute Options from Salem (15 H/C)		0	0	0	0	0	0
Sub-Total		1798	0	0	0	0	0
Reengineering Capital Requirements:	$K						
Capital Depreciation-Dock Doors	410	39	37	35	33	31	29
Capital Depreciation-SAM	925	206	180	154	128	103	77
Capital Depreciation-Core B	150	33	29	25	21	17	13
Capital Depreciation-AKO	0	0	0	0	0	0	0
Sub-Total	1485	278	246	214	182	151	119
Other Program Expenses:							
Loss of Tenant Rent		0	0	0	0	0	0
Total Cost		2076	246	214	182	151	119
Net Program Savings/(Loss)		2095	2079	2111	2143	2174	2206
Cumulative Program Savings/(Loss)		2095	4174	6285	8427	10601	12808
Cash Flow Analysis:							
Add Back Depreciation		278	246	214	182	151	119
Add Back Asset Writeoff		500	0	0	0	0	0
Less Capital Outlay		1485	0	0	0	0	0
Equals Cash Flow - Annual		1388	2325	2325	2325	2325	2325
Equals Cash Flow Cumulative			3713	6038	8363	10688	13013
Net Present Value @20% - Annual		1388	1937	1614	1346	1121	935
Net Present Value @20% - Cumulative			3325	4938	6284	7405	8340
Payback Period - Months		6					

Americas Manufacturing & Distribution
Salem Plant Reengineering Program
Savings/Cost Analysis - $K

Iteration 4	Total Digital Build New Addition Move Tenants to New Building Move Shipping & Options to Core B

	$K	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Reengineering Program Savings:							
Reduced Labor - SAM/Shipping (50 H/C)		1604	1604	1604	1604	1604	1604
Freight Savings for Shipping Move		170	170	170	170	170	170
DAS Warehouse Savings for Shipping		0	0	0	0	0	0
DAS W/H & PPS Options Savings		472	472	472	472	472	472
Intransit Merge Minimization-DEC		168	168	168	168	168	168
Intransit Merge Minimization-Customer		672	672	672	672	672	672
Shortship/Misship Improvements		120	120	120	120	120	120
Inventory/Cycle Time Reduction for SAM		2277	431	431	431	431	431
Total Savings		5483	3637	3637	3637	3637	3637
Reengineering Program Costs:							
Consolidate Mfg. Processes		390	0	0	0	0	0
Implement Salem Assembly Module		732	0	0	0	0	0
Move Tenants		100	0	0	0	0	0
Asset Writeoff for Tenant Move		1450	0	0	0	0	0
Defit Core B		557	0	0	0	0	0
Refit Core B		200	0	0	0	0	0
Move Shipping from DAS to NIO		76	0	0	0	0	0
Distribute Options from Salem (15 H/C)		750	750	750	750	750	750
Sub-Total		4255	750	750	750	750	750
Reengineering Capital Requirements:	$K						
Capital Depreciation-Dock Doors	460	44	42	39	37	35	33
Capital Depreciation-SAM	925	206	180	154	128	103	77
Capital Depreciation-Lab/Admin/Core B	2182	485	424	364	303	242	182
Capital Depreciation-New Building	2800	267	253	240	227	213	200
Sub-Total	6367	1001	899	797	695	594	492
Other Program Expenses:							
Incremental Operating Cost - New Building		350	350	350	350	350	350
Total Cost		5606	1999	1897	1795	1694	1592
Net Program Savings/(Loss)		(123)	1638	1740	1842	1943	2045
Cumulative Program Savings/(Loss)		(123)	1515	3255	5096	7040	9085

Cash Flow Analysis:	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Add Back Depreciation	1001	899	797	695	594	492
Add Back Asset Writeoff	1450	0	0	0	0	0
Less Capital Outlay	6367	0	0	0	0	0
Equals Cash Flow - Annual	(4039)	2537	2537	2537	2537	2537
Equals Cash Flow Cumulative		(1502)	1035	3572	6109	8646
Net Present Value @20% - Annual	(4039)	2113	1761	1469	1223	1020
Net Present Value @20% - Cumulative		(1926)	(165)	1304	2527	3547
Payback Period - Months			31			

Americas Manufacturing & Distribution
Salem Plant Reengineering Program
Savings/Cost Analysis - $K

Iteration 5	Total Digital Do Not Move Tenants Move Shipping/Keep Options in Das 80% SAM Implementation

	$K	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5
Reengineering Program Savings:							
Reduced Labor - SAM/Shipping (50 H/C)		1304	1304	1304	1304	1304	1304
Freight Savings for Shipping Move		170	170	170	170	170	170
DAS Warehouse Savings for Shipping		0	0	0	0	0	0
DAS W/H & PPS Options Savings		0	0	0	0	0	0
Intransit Merge Minimization-DEC		0	0	0	0	0	0
Intransit Merge Minimization-Customer		0	0	0	0	0	0
Shortship/Misship Improvements		120	120	120	120	120	120
Inventory/Cycle Time Reduction for SAM		2054	388	388	388	388	388
Total Savings		3648	1982	1982	1982	1982	1982
Reengineering Program Costs:							
Consolidate Mfg. Processes		390	0	0	0	0	0
Implement Salem Assembly Module		712	0	0	0	0	0
Move Tenants		0	0	0	0	0	0
Asset Writeoff for Tenant Move		0	0	0	0	0	0
Defit Core B		0	0	0	0	0	0
Refit Core B		0	0	0	0	0	0
Move Shipping from DAS to NIO		76	0	0	0	0	0
Distribute Options from Salem (15 H/C)		0	0	0	0	0	0
Sub-Total		1178	0	0	0	0	0
Reengineering Capital Requirements:	**$K**						
Capital Depreciation-Dock Doors	410	39	37	35	33	31	29
Capital Depreciation-SAM	875	194	170	146	122	97	73
Capital Depreciation-Core B	0	0	0	0	0	0	0
Capital Depreciation-AKO	0	0	0	0	0	0	0
Sub-Total	1285	233	207	181	155	128	102
Other Program Expenses:							
Loss of Tenant Rent		0	0	0	0	0	0
Total Cost		1411	207	181	155	128	102
Net Program Savings/(Loss)		2237	1775	1801	1827	1854	1880
Cumulative Program Savings/(Loss)		2237	4011	5812	7640	9493	11373

Cash Flow Analysis:						
Add Back Depreciation	233	207	181	155	128	102
Add Back Asset Writeoff	0	0	0	0	0	0
Less Capital Outlay	1285	0	0	0	0	0
Equals Cash Flow - Annual	1185	1982	1982	1982	1982	1982
Equals Cash Flow Cumulative		3167	5149	7131	9113	11095
Net Present Value @20% - Annual	1185	1651	1376	1148	955	797
Net Present Value @20% - Cumulative		2836	4212	5359	6314	7111
Payback Period - Months	5					

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