Pan-European Durable Container Strategy

by
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Submitted to the Sloan School of Management and the Department of Electrical Engineering and Computer Science in Partial Fulfillment of the Requirements for the Degrees of

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ABSTRACT

Ford Motor Company of Europe purchases automotive components that are packaged in either durable reusable containers or expendable (cardboard) containers. This thesis evaluates the pan-European durable container strategy. Durable containers are a significant part of Ford's greening strategy to minimize solid wastes. In addition, durable containers improve freight trailer volume utilization. This thesis performs a benchmarking exercise of the existing 1996 – 2001 contract for the Folding Large Container (FLC) and Folding Small Container (FSC) as well as a benchmarking exercise of durable container strategies of other automotive companies and other industries. This thesis includes strategies for authoring a specification and sequential contract, along with quotation analysis of suppliers' proposals. Also, this thesis evaluates pan-brand container management strategies for the Ford Motor Company European family of vehicles, Ford, Jaguar, Land Rover, and Volvo.

A supply chain logistics model of the container management was developed. Currently, 98% of all automotive components are packaged in durable containers, and 40% utilize the FLC/FSC. Ford of Europe makes use of the more expensive cardboard container as the alternative to the FLC/FSC. The internship and thesis addressed expendable packaging as cost reduction opportunities. The data collected was complied into the base stock logistics model, which utilizes expected inventory, cycle stock, and safety stock. Safety stock, which is stored at the Ford assembly plants, was modeled as a function of the vehicle production variance and the ratio FLC/FSC per vehicle. The logistic model is a container management tool that addresses the ideal safety stock per region to avoid shipping empty containers long distances, which is time-consuming and costly. In addition, the logistics model is optimized to find the best-cost function with respect to empty container freight, container pool size, and expendable risk. Most importantly, the logistics model produces an optimal shipping template for the empty containers' return trip to the component suppliers.

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Table of Contents

Chapter 1: Introduction

1.1 Overview

Ford Motor Company currently leases Folding Large Containers (FLC) and Folding Small Containers (FSC) from a third party supplier also known as the Durable Container Provider (DCP). In addition to container leasing, the Durable Container Provider furnishes container management as part of the existing five-year FLC/FSC contract that will terminate in May 2002. The internship was a benchmarking exercise to determine the Best-In-Class FLC/FSC service. The analysis consisted of a business case study and an engineering supply chain model to determine the optimal costing structure and logistics performance. The thesis illustrates container management with optimal service levels.

1.2 Company and Business Background

Europe is Ford Motor Company's second largest market in both vehicle production and revenues. In the last decade, the European governments have been very progressive in implementing environmentally friendly legislation. The European laws include costly penalty and disposal fees for expendable (cardboard) containers. In 1995, Ford furthered their Greening Strategy by replacing a significant number of expendable containers with the introduction of reusable durable plastic Folding Large Containers. The DCP contract includes container asset leasing and container management of the empty containers from the assembly plants to component suppliers, where the containers are refilled with automotive components, then shipped back to the assembly plants to complete one full cycle. In 1999, Ford introduced a smaller container, called the Folding Small Container. Currently, the FLC and FSC pool size is approximately 210,000 and 20,000, respectively. The asset value of the FLC/FSC pool is $24 million. The total cost to Ford equates to $19 million annually for the FLC/FSC process, which mostly comprises the container leasing, container management, and empty container freight. The current cost savings from the FLC/FSC Greening Strategy is $10 million annually as a result of replacing expendable containers with less expensive reusable FLC/FSC.

1.3 Thesis Objective

The FLC/FSC container process includes inefficiencies, which results in wastes in the order of millions of dollars annually for Ford Motor Company. The requirements were to determine and quantify these inefficiencies and develop improved processes. Since the current leasing contract terminates in May 2002, the opportunity exists to rectify all issues including those constrained by contractual agreements.

1.4 Scope

The thesis includes a discovery of the current process, contract, and stakeholder issues. The process observation included benchmarking the automotive industry and other non-automotive industries. The supermarket industry benchmarking produced valuable information due to the industry's high volumes and short shelf lives of many products. Working closely with engineers and accountants, wastes and inefficiencies were determined and quantified. A core team of three individuals developed process strategies to promote mutually beneficial rewards for all stakeholders. A new specification and sequential contract, which continuously reinforces the proper behaviors, were developed. Four Durable Container Providers submitted quotations. A financial and engineering analysis was conducted to evaluate the quotations and determine a robust service with the best value.

As part of the Ford Greening/Environmental Strategy, the FLC containers have been introduced to replace expendable containers. Occasionally, the automotive component suppliers utilize expendable containers when FLC containers are not immediately available. Automotive components cannot be delayed to the assembly plants due to the enormous costs of assembly plant production stoppages, which are approximately $15,000 per minute for Ford European assembly plants.[1] In addition, the European plants discourage expendable packaging because of higher total cost to the plant. The thesis will assess the expendable costs and risks and determine the optimal safety stock. Furthermore, the thesis will develop a logistics model utilizing supply chain principles. The model will include inventory and safety stocks for both vehicle assembly region and vehicle model allowing flexibility. The optimization software "Solver" will be utilized to determine the optimal total cost solution for the logistics model, which will be a

[1] Ford of Europe Manufacturing Finance

function of expendable and associated costs, durable container pool size, safety stock, and empty container freight, as well as balancing containers among the users. The thesis will also evaluate a cross brand strategy among Ford, Jaguar, Land Rover, and Volvo and determine the optimal logistics model for Pan-Europe.

Chapter 2: Durable Containers and Process

2.1 Folding Large and Folding Small Containers

The Folding Large Container was developed to replace large cardboard boxes, which are recycled in Europe. In addition, European laws discourage expendable containers and encourage reusable plastic containers. The FLC constructed with high-density polyethylene has a width of 1.0 meter, a length of 1.2 meter, and a height of 0.975 meters. The greatest volume utilization occurs in the most popular Megatrailer/Supercube that has a width of 2.45 meters, a length of 13.6 meters, and a height of 2.95 meters. A truck is said to "weigh out" when it reaches its weight limitation; it is said to "cube out" when it reaches its volume (space) limitation.[2] The FLC has other advantages over cardboard, like its container wall strength and stackability. FLC containers can be stacked three high without the threat of collapsing under the weight of their contents, automotive components. Most cardboard containers of equal size to the FLC can only be stacked two high resulting in one third less trailer shipping utilization. The Megatrailer allows for seventy-eight erected FLC containers. Both the FLC and FSC are foldable to a height of 0.4 meters to reduce empty container freight. The Megatrailer allows for seven empties high FLC and FSC, which equates to a full truckload of one hundred and eight-two empties. Empty FLC and FSC can safety be stacked up to fifteen high. Since the Megatrailer allows for seven high, most warehouses will stack empty FLC and FSC fourteen high so that the forklift process can be lean and efficient.

Durable containers are also advantageous for ergonomic issues. The FLC and FSC are often found on the manufacturing shop floor tilted towards the assemblers, who are subject to ergonomic issues such as back problems from excessive leaning. Durable containers made of plastic or steel have the container wall strength necessary to tilt heavy automotive components towards the assembler, as opposed to cardboard containers that will typically collapse under the weight of heavy automotive components. The FLC and FSC have access doors with hinges and handles mounted into the sides of the containers to further address ergonomic issues. For more information about the Folding Large and Small Containers, see Appendix F: Ford Packaging Guidelines for Externally Purchased Parts, Vehicle Operations - Europe, April 2000.

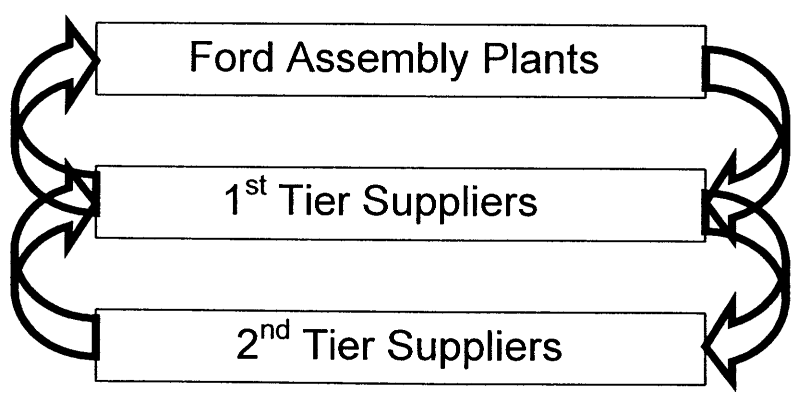
[2] Janice H. Hammond, "Barilla SPA (C) casestudy", *Harvard Business School*, Boston, Massachusetts (1995).

2.2 Process Overview

Throughout Europe, FLC/FSC (FXC) containers are filled with automotive components by two hundred and seventy suppliers and shipped to one of the seven Ford assembly plants. The Empty Pallet Compounds (EPC) will store most of the available container safety stock, while some of the safety stock is stored in warehouses near the assembly plants/EPCs. The containers are transported to the assembly plants by Ford transportation and their transportation supplier, Lead Logistics Partner (LLP). At the assembly plant, the component carrying containers are distributed to the production line side for vehicle assembly. The empty containers are collected and sorted for damage at the Empty Pallet Compounds located within the assembly plants. The Empty Pallet Compounds are usually located in close proximity to the distribution warehouse so that trailer movements can be minimized. Many trailers transport components from suppliers to assembly plants and transport empty containers and pallets back to the suppliers. Damaged containers are either repaired locally at the Empty Pallet Compounds or sent to a local repair shop. The Lead Logistics Partner will arrange transportation for the empty FXC containers back to the component suppliers.

In 1995, Ford of Europe reviewed their environmental need to remove cardboard containers from their supply chain. From this environmental initiative, Ford developed durable container strategies to further "green" their supply chain. One main driver for a standard universal container is based on the empty pallet strategy, where you have a large pool with many different uses for many different industries where all stakeholders benefit from the standardization. When a container or pallet is empty, it is most cost effective to transport it the shortest distance for reuse by anyone. For example, an empty container or pallet traveling on a truck has little to no value-added. Usually, there is no need to ship standardized empty pallets across Europe or any long distance. Most often any wood pallet is the same as the next wood pallet. Unfortunately, the automotive industry is greatly burdened with specialized containers and shipping racks. The best example of inefficient empty container shipping is engine racks, where most are not interchangeable between engines, let alone another application outside the automotive industry. In addition, most engine racks must go back to a specific engine plant. The empty engine rack's return trip is all deadweight loss – net loss of total (consumer and producer) surplus.[3] The FLC and FSC were designed as standard containers to be used for more than the automotive industry. There are some functions for the FLC and FSC outside the automotive industry, but unfortunately these functions are still only a few. Automotive durable containers are any reusable component container used in vehicle operations. Ford of Europe owns many durable containers, which have been estimated to have a value of $300 million dollars. The Ford supply chain includes supplier owned containers that also have a substantial value. Ford puts all their effort into processes to build vehicles. Ford would rather contract the container management services to a supplier along with the ownership of the containers. After the vehicle is assembled, Ford employees have other priorities than empty containers. The market forces from the lack luster attitude of Ford employees towards empty containers reinforces the strategy of third party supplier (Durable Container Provider) owned and operated containers. In addition, Ford of Europe has also determined container management as a non-core competency. The combination of durable container strategies, large standardized container pool, and empty container management as a non-core competency, resulted in the decision that a third party supplier should own, manage, and lease the FLC and FSC containers to Ford and their component suppliers. A new three-year contract will commence May 2002.

Durable Container Logistics



[3] Pindyck, Robert S.; Rubinfield, Daniel L, "Microeconomics Fifth Edition," *Prentice Hall,* Upper Saddle River, New Jersey, (2001), p. 292.

Ford assembly plants communicate with their component suppliers through an electronic link called the Common Manufacturing Management System (CMMS-3). The suppliers are aware of the projected build approximately a month in advance. The final component orders are confirmed one or two weeks prior to actual production via the Advance Shipping Notice (ASN). The suppliers will ship components in a variety of packaging including the FLC and FSC. As suppliers use FXCs, they will order empties from the third party container leaser, Durable Container Provider. The current Durable Container Provider communicates daily with the component suppliers via fax and phone. The new Durable Container Provider starting May 2002 will primarily communicate with the component suppliers via internet with fax and phone calls as a secondary communication link. The new process will allow component suppliers to order many weeks in advance with daily reviews. The leadtime to fill supplier orders is five days of process plus the shipping time from their supportive assembly plants. The Durable Container Provider will process most orders within twenty-four hours. The Lead Logistics Partner responsible for the empty container shipping will process orders in forty-eight hours as they optimize shipping routes and trailers. Most often the process time for the Durable Container Provider and Lead Logistics Partner is three days, but the component suppliers are requested to order in advance to allow five days for processing plus the respective delivery time. Below are the shipping times in days from the Empty Pallet Compounds found within the assembly plants to the component suppliers grouped by country.

Table 2.2.A

Ford Transit Times

	FORD ASSEMBLY PLANTS						
Component Suppliers	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	9	5	8	5	5	10	8
France	4	4	5	3	3	4	4
Hungary	5	5	6	5	5	5	8
Italy	4	3	5.5	3	3	4	4
Netherlands	3	1	5.5	1	1	4	3
Poland	8	6	9	6	6	9	8
Portugal	5	5	5	5	5	4	2
Slovakia	9	5	8	5	5	10	8
Sweden	5	6	5	6	6	5.5	6
Switzerland	5	6	6	2	1	5	5
Belgium	2	4	4	1	1	3	3
Germany	3	5.5	5.5	1	1	3	3
United Kingdom	1	1.5	1.5	3	3	0.8	5
Spain	5	5.5	5.5	4	4	6	1

As vehicles are assembled within the Ford factories, containers become empty and are transported to the Empty Pallet Compounds, where the containers become available for the component suppliers. The ratio of FXC per vehicle is a function of component size and shipping dunnage (packing-dividers that separate and protect the components). The ratio of containers per vehicle and location (A_{IL}) can be found in Section 6.1.2, Table 6.1.2.A. The combination of container ratio, vehicle production, and vehicle production variance determine the amount of containers available at the EPCs. The most influential factor of available containers is production variance. Some assembly plants like Genk, Belgium traditionally have high production variance, which causes high variability in their respective safety stock. When safety stocks become depleted and containers are not available for the return trip back to the component suppliers, alternative packaging like cardboard is usually utilized. Component suppliers would never stockout an assembly plant due to lack of durable packaging, since production stoppages at Ford European Plants cost approximately $15,000 per minute.

During the twelve months of June 2000 through May 2001, Ford of Europe produced 1,505,914 vehicles. The models included Ka, Fiesta, Focus, Mondeo, Transit, and Escort. The production regions are grouped into three regions German (Genk, Belgium; Cologne, Germany; Saarlouis, Germany), British (Dagenham, England; Halewood, England; Southampton, England), and Spanish (Valencia, Spain). Daily vehicle production variance by model can found in Section 6.1.2 Table 6.1.2.A. The total FXC container movements over the same period were 2,694,654.

Table 2.2.B
Vehicle Production from June 2000 through May 2001

	ASSEMBLY PLANTS						
	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
	Fiesta	Mondeo Transit	Escort	Fiesta	Focus	Transit	Focus Ka
	109,652	265,414 99,026	36,796	222,822	381,231	58,728	189,440 142,805
Subtotals		*364,440*					*332,245*
Total Vehicles 6/00 - 5/01			1,505,914				

GERMAN	64%
BRITISH	14%
SPANISH	22%

Table 2.2.C

Ford Demand Jun-00 through May-01, Component Suppliers to ASSEMBLY PLANTS
Total Container Movements for Europe

	FORD ASSEMBLY PLANTS						
Component Suppliers	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	3,177	38,187	0	9,243	68,778	6,523	39,777
France	3,916	133,821	5,514	8,363	150,711	29,819	82,844
Hungary	900	22,227	243	1,810	12,086	576	5,894
Italy	8,824	39,579	2,268	20,455	22,902	5,626	13,789
Netherlands	16	14,436	6	0	5,203	1,245	2,782
Poland	1	4,534	0	0	454	234	9,489
Portugal	1,024	4,645	413	2,058	4,904	495	7,745
Slovakia	0	1,102	0	0	553	0	255
Sweden	0	0	0	0	3,144	0	1,835
Switzerland	0	3,471	0	0	30	0	0
Belgium	104	13,164	7,747	479	72,393	0	8,670
Germany	33,369	181,167	0	74,835	176,392	13,605	93,046
United Kingdom	52,061	129,283	14,833	81,724	236,336	43,263	100,843
Spain	20,739	113,737	5,641	50,445	135,654	19,882	207,316
Subtotals	124,131	699,353	36,665	249,412	889,540	121,268	574,285
Total Container Movements	2,694,654						

The approximately number of containers in the pool is 210,000 FLC and 20,000 FSC. The number of annual container movements (2,694,654) divided by the container pool size (230,000) yields yearly turns of 11.7, which equates to 31.2 calendar days for cycle time. Cycle time is the amount of time a container takes to travel completely through the process. Due to data collection constraints, the annual movements of 2,694,654 are estimated.

2.3 Durable Container Provider

As mention in Section 2.2, Ford Motor Company's durable container strategy is the use of a standard container that has the capability to be used for more than the automotive industry. In addition, it is preferred that a third party own and manage the standard containers for Ford and their component suppliers. The Durable Container Provider manages empty container requirements and requests container movements via the Ford Transportation network. The DCP also coordinates repairs and all necessary logistics involved with the process. Additionally, the DCP will champion accountability of the complete process including all failures. The DCP will monitor the container process sufficiently and hold the appropriate stakeholders accountable for their process failures; otherwise the DCP will accept full financial accountability for the failure.

2.4 Component Suppliers

Ford Motor Company specializes in vehicle design and assembly. Ford purchases components from suppliers and assembles them into the final product, vehicles. The European FXC process includes two hundred and seventy component suppliers, located in fourteen countries, who utilize the FLC and FSC for packaging. The fourteen countries are Belgium, Germany, United Kingdom, Spain, Czech Republic, France, Hungary, Italy, Netherlands, Poland, Portugal, Slovakia, Sweden, and Switzerland. For this thesis and supportive calculations, the component suppliers are grouped into four regions: Germany (Belgium and Germany), United Kingdom, Spain, and the 4^{th} region representing the ten countries of Czech Republic, France, Hungary, Italy, Netherlands, Poland, Portugal, Slovakia, Sweden, and Switzerland.

2.5 Transportation Group

Ford of Europe coordinates material movement through the Ford Transportation Group. Logistics engineers work in conjunction with purchasing professionals to assure robust and cost effective transportation routes. The transportation group also contracts shipping routes with the Lead Logistics Partner (LLP), which is a joint venture of Ford Motor Company, Exel, and UPS. The joint venture company performs in-depth analysis of the total supply chain determining cost saving opportunities. Total cost includes transportation cost and inventory holding costs. The Lead Logistics Partner receives the component suppliers' empty container requests from the Durable Container Provider and optimizes empty container freight from the assembly plants to the awaiting component suppliers.

2.6 Process Costing

An important part of any quantifying process is the identification of true costs per action. Once true costs are established cost savings opportunities may commence. Within the new specification, the core team stressed the importance of having these costs promote the desired behavior. Within Section 4.2, Activity Base Costing (ABC) allows an organization to fully understand the process and goals of a system. Also, strategies and incentives must be aligned to obtain the desired behaviors. True process costs, or the ABCs, quantified the logistics model in Chapter 6 and 7, which ultimately was optimized to reduce total cost.

The logistics model uses the annual cost of €64.08 per container for those that are a component of safety stock. This assumes the price of a new container is €200 per FLC or FSC amortized over the expected life cycle of ten years. Annual amortization costs are €20 per container. The cost of capital is assumed to be 10%; hence the annual cost of capital is also €20 per container. Most containers are a component of the cycle stock within the process. The containers that are a component of the safety stock are located at the Empty Pallet Compounds within the Ford assembly plants. The Ford annual real estate cost for each FLC in safety stock is €24.08.

As containers are moved across Europe from the Empty Pallet Compounds to the awaiting component suppliers, the container will travel on the trucks and affect the outbound empty container inventory. Shorter time on the trucks will result in fewer containers. The logistics model applies the Ford Transit Times (Table 6.1.1.B) to the outbound empty container routes. The optimization software will find the best routes with respect to point-to-point transportation costs and outbound empty container inventory pool size impact. The optimal solution requires 2.0038 days of outbound transit. See Section 6.1.1 for further information.

2.7 Cost of Failures

A failure in the FXC process occurs when a FXC is not immediately available for the component supplier. In vehicle assembly plants, line side feeds are arranged with durable containers. Components arriving in any container besides the originally specified container causes some disruption of the assembly process. For example, the line side process expects a predetermined number of components per container. Material handling replenish intervals are based on components per container for the vehicle mix. Component suppliers cannot be delayed from shipping components to the assembly plants due the enormous costs of vehicle assembly production stoppage. Most often component suppliers will use expendable cardboard containers when FXC containers are not available.

The Ford – component supplier contracts are such that Ford provides the container at no cost to the component supplier. Most often the component piece price has no container or shipping costs attached. When durable containers are not available, the component supplier will invoice Ford the cost for each cardboard container. A cardboard container of equal size to the FLC costs approximately €22.56 ($20.08).

Cardboard is a recyclable product and most European manufactures have to pay fees to dispose of the cardboard. Disposal costs vary from location to location. The average disposal fee for a cardboard box of FLC size is €2.08 ($1.85).

The durable container has benefits for line size feed, for example the FLC container walls do not crush like cardboard containers. When the container walls crush, the components within may become damaged. Also, large deep containers are an ergonomic issue for the operators from the repetitive bending over. The FLC also has side access doors to assist the operator. At line side, large containers are elevated and tilted towards the operator to further address ergonomic issues. Unfortunately, most cardboard containers collapse from the components weight when they are tilted. To avoid the cardboard collapsing from the tilting necessary to avoid ergonomic issues, cardboard containers are repacked into FLC containers. The repacking cost was determined to be approximately €4.48 ($3.99). The forklift and janitor impact from an expendable container is €5.67 ($5.05).

All successful manufacturing processes depend on stable repetitive process. Component suppliers do not always give advance notice to the shipping carrier that the components are packed in cardboard instead of the standard FLC. This communication failure causes chaos for the carrier and assembly plant. Cardboard containers do not have the strength that FLC containers contain. Fully loaded, FLC containers can be stacked five high while their size equivalent in cardboard can only be stacked two high. Most European trucking is done with the Megatrailer/Supercube that accepts FLC three high. Cardboard instead of FLC results in one-third waste of shipping utilization, which equates to inbound freight impact of €10.38 ($9.24) per failure. Total impact to Ford for each failure where a cardboard container is used instead of the correct FLC container is €45.18 ($40.21).

Cardboard Box	€	22.56
Disposal per Box	€	2.08
Repacking per Box	€	4.48

Forklift and Janitor Impact	€	5.67
Inbound Freight Impact	€	10.38
Cost per Failure	€	45.18

Chapter 3: Benchmarking Best-In-Class

Ford of Europe wanted a new contract that was Best-In-Class. To accomplish this task a core team of three people was assembled: Adrian Walker, Material Handling & Packaging Engineering Supervisor, Adrian Merrylees, Purchasing Supervisor, and this thesis author - Tony Palumbo, Ford Fellow at Massachusetts Institute of Technology, Leaders for Manufacturing Program. Their deliverables included benchmarking the existing process, existing contract, other automotive manufacturers, and non-automotive industries. The core team's hard work resulted in a new specification and contract for the Ford of Europe FLC and FSC durable container process that encourages all stakeholders to work as a team. Chapter 3 benchmarks four industries to discover how the existing Ford FXC process can be improved to become Best-In-Class.

3.1 Supermarket Industry

The supermarket industry uses many plastic durable containers for a variety of products like frozen foods, vegetables, and fresh fish. The supermarket chains and their suppliers utilize the containers while a third party durable container provider will manage the containers similar to the automotive industry. The relatively short shelf life of food poses some real challenges. The durable container providers in this industry usually charge the stakeholders relativity expensive daily lease (hire) fees to discourage the stakeholders from retaining containers, instead encouraging the stakeholders to turnover containers. The strategy of "hot potato" with the containers is necessary to reinforce the desired behavior of getting the product and container to market quickly. The supermarket industry requires intense cleaning of the containers after every use. Similar to the automotive industry, excessive handling of product results in damaged product, for example bruised tomatoes. The supermarket industry, like the automotive industry, will put containers and product directly on the shelf (line side) without re-handling. Unlike the automotive industry, the supermarket's end-user (customer) feels and smells the product along with the container that carried it to market. If tomatoes smell like fish from a poorly cleaned container, the supermarket customer would not purchase the tomatoes. From tomatoes to fish, the cleanliness of the product and container is very important to the supermarket industry. In addition, the container's color, size, and shape are all integral parts of the food product marketing to the consumer. The profit mark up on groceries is small, usually a few percentage points. With very little room for inefficiencies, the supermarket industry relies heavily on inexpensive internet technologies to track containers. The small profit constraints and short shelf life product make the supermarket industry a worthwhile benchmarking exercise.

3.2 Periodical Industry

The periodical industry consists mainly of newspapers and magazines, which have a range of life spans from daily to monthly. The dated material within the authors' articles complicates the relatively short life span of daily and weekly product. In addition to timing and speed to market, the traceability of the product and container are all very critical in the periodical industry. Like the supermarket industry, the periodical industry relies heavily on inexpensive internet technology as a cost effective method to track containers.

3.3 Milk Industry

The American and British milk industries have done excellent jobs of implementing standardized milk packaging and containers (milk crates). The American milk producers have overcome a huge problem of milk crate leakage (loss/stolen). For many decades, the most popular bookshelf and furniture for American college students was plastic milk crates. American college students are not the only ones who have illegally used milk crates; milk crates have been found in most family garages. In the late eighties, American legislation placed $300 fines for stolen and unauthorized use of milk crates. The warning has been placed on every milk crate. Unfortunately, the warning and dormitory raids were not enough to overcome the market forces for college bookshelves and furniture and the family garage storage bin. The need to pilfer milk crates by Americans was finally overcome with the help of department stores who legally sell generic crates to the American public. The British addressed the leakage issue by standardizing a container that has plastic dividers injection molded into the design. The dividers not only protect the bottles from touching one another, but also the dividers render the milk crate virtually useless for anything other than transporting milk bottles.

With the leakage issued properly addressed, the American and British milk industries capture the greatest benefits of pooling a standard interchangeable milk crate. After milk cartoons and bottles are removed from the milk crate, the milk crate is mixed with other milk crates and no effort is necessary to sort the crate back to any particular milk producer. Most milk crates are treated as generic milk crates. A milk producer may or may not receive his crates back from the supply chain. The milk producers are satisfied with the one-for-one exchange and container deposit method where the containers are mixed, because they all are of equal value and usefulness. The milk industry is an excellent example of a standardized container pool.

3.4 Automotive Industry

Of the four industries benchmarked, the automotive industry has the most expensive container carrying the most expensive product. The automotive industry spends a significant amount of money to track the containers from location to location. These costs are becoming more affordable with the application of inexpensive internet technology.

The FLC, FSC, and smaller KLT containers were designed to maximize the shipping trailer utilization. The European KLT container pool is used most by Ford and General Motors, 30% and 60% respectively. The remaining 10% are non-automotive applications. For more information on the FLC, FSC, and KLT containers see Appendix F: Ford Packaging Guidelines for Externally Purchased Parts, Vehicle Operations - Europe, April 2000. The automotive industry would prefer empty containers to travel the shortest distance back to component suppliers; hence, a large standardized pool with many uses is critical.

The automotive industry, like other industries, has leakage issues. One inexpensive method to address the need to pilfer the containers was to sell containers within the assembly plants and component supplier locations. Within Ford Motor Company of Europe, there are many sizes of plastic containers, which are usually of three main container colors: blue, black, and green. Since white containers are not used for automotive components, Ford Motor Company sells white containers at their general stores for non-production uses within the plants. The color distinction allows Ford to police their plants quickly for improper use of durable containers.

The existing process has little control over the FLC leakage. In addition, the existing contract does not hold the appropriate stakeholders accountable for their leakage. Unfortunately, Ford Motor Company has been paying for all container process leakage even though the containers remain in Ford's possession the least amount of time out of any stakeholder. The average cycle time for a FLC container is approximately thirty-one calendar days, of which only three days are actually within the Ford assembly plants. The core team believes that a robust tracking system is necessary to stop the leakage. The new specification and contract are very clear that the Durable Container Provider must hold the appropriate stakeholders accountable for their leakage. If the new Durable Container Provider cannot provide sufficient documentation of how and when the leakage occurred, then the Durable Container Provider will financially and/or physically replace the lost containers.

After the first four years of the FLC process, a physical audit determined that thirty thousand FLC containers were missing. Ford Material Handling and Packaging Engineering replaced the containers in a concerted effort to support their customers: Ford assembly plants, component suppliers, and the transportation group. In addition with every model, more and more components were sourced in FLC containers. The initial pool purchase was 150,000 containers with additional purchases of 25,000 per year. Table 3.4.A utilizes the optimization software "Excel Solver" to model the leakage issue over the first four years. The target cell was set equal to the leakage of thirty thousand. The decision variable of leakage ratio was determined to be 4.23%. Therefore, it is estimated that during the first four years of the FLC process an annual leakage of 4.23% occurred.

Table 3.4.A
FLC Leakage Calculation

Year	Container Pool Size	Leakage Ratio	Lost Containers	Greening Purchases from MH & PE: FLC
1997	150,000	0.042326	***6,349***	150,000
1998	168,651	0.0423	***7,138***	25,000
1999	186,513	0.0423	***7,894***	25,000
2000	203,618	0.0423	***8,618***	25,000
Lost Containers over the First Four Years			***30,000***	

Chapter 4: Change the Rules of the Game in a new Specification

Ford of Europe Material Handling and Packaging Engineering department is the Ford champion of durable containers. The existing contract was expected to terminate in February 2002, but was extended to May 2002 due to the timing of other launches. In late 2000, the MH&PE area manager decided to acquire additional Ford help from outside the department. The Massachusetts Institute of Technology – Leaders for Manufacturing intern, who is also a Ford employee, was recruited to assist from June 2001 through December 2001. Some of the deliverables included benchmarking existing processes and issuing a new specification to suppliers for a competitive bid. Due to the confidential nature of the Ford and supplier quotation process, an intern who was also a Ford employee was preferred. The core team developed a specification that allowed the four Durable Container Providers who were bidding on the new three-year contract to demonstrate their creativity to operate the most efficient Best-In-Class process and to demonstrate a disciplined robust service. See Appendix B: Executive Summary for DCP Specification. In addition, Chapter 4 demonstrates the method to obtain a total cost durable container process that mutually benefits all stakeholders.

4.1 Removing Constraints and Encouraging the Right Behavior

A constraint restricts a stakeholder or process. Some constraints are instituted to protect the stakeholders in the process. Self-optimization by one stakeholder may result in financial loss to another stakeholder. As part of the benchmarking procedure, the core team reviewed the constraints and developed a new specification that would remove inefficient constraints and encourage the right behavior thus benefiting all stakeholders.

The FLC/FSC container process has four primary stakeholders: Ford Motor Company, two hundred and seventy component suppliers, the Durable Container Provider, and the Lead Logistics Partner. In 1995, Ford initiated the FLC/FSC process as a cost savings and environmentally friendly strategy. Unfortunately, the initial five-year contract did not address all self-optimization strategies and the process was not a total cost optimization that mutually benefited all stakeholders. The replacement three-year contract was a total cost approach so that all stakeholders had the opportunity to continuously improve and obtain the benefits of their hard work. Within this section, we will examine the strategies that promote teamwork and benefit all stakeholders.

The core team reviewed the most contested constraint – empty container freight. Ford Motor Company was financially responsible for the empty container freight, which represented approximately thirty-five percent of Ford's annual cost for the FLC/FSC process. Within the existing contract, the Durable Container Provider had neither the incentive nor any metric to measure the empty container freight. With very little regard for empty container freight, the Durable Container Provider did not fulfill Ford's needs to reduce its overall container costs. Since Ford paid the empty container freight, Ford logistics engineers micro-managed the Durable Container Provider's empty container sourcing decisions.

When component suppliers lack durable containers they use expendable containers, which results in more additional cost to Ford. For more information about failure cost see Section 2.7 Cost of Failures. Ford of Europe needed a logistics model demonstrating the total cost approach for containers and empty container freight. The intern developed a model using advanced optimization software that represents the total cost approach, which is presented in Chapters 6 and 7. Most importantly, Ford of Europe logistics engineers now have an empty container-shipping template (Section 7.2.5) that incorporates total cost. The optimal cost solution is the new benchmark by which the Durable Container Provider's performance is evaluated.

The Durable Container Provider, who owns and manages the containers, is the most significant stakeholder of the process. The component suppliers make requests for containers from the Durable Container Provider seven days in advance. The Durable Container Provider will process the request and forward the information onto the Lead Logistics Partner within three days. The Lead Logistics Partner is responsible to find the best method to deliver empty FLC/FSC containers from the assembly plants to the awaiting component suppliers. The Lead Logistics Partner will utilize their resources (knowledge and shipping routes optimization software) and determine the best method to transport the empty containers from the assembly plants to the awaiting component suppliers. To accommodate the Lead Logistics Partner's optimization, two days is required before a truck is scheduled. The remaining two days of the seven is for shipping.

Ford has also looked at other strategies to promote efficiencies and Best-In-Class in their supply chain. Automotive components are of higher quality and less expensive if they are handled the fewest number of times within the supply chain. To further assist the supply chain, Ford allows the component suppliers to maintain containers in the amount equal to five days worth of production at no cost to the component suppliers. Ford encourages the component suppliers to integrate the FLC and FSC containers as part of their Work-In-Process to help reduce their costs, since component suppliers' costs are an integral part of the larger Ford supply chain. Some suppliers may find it economically feasible to hold onto containers for time periods longer than five days. Unfortunately, the longer period of time that a component supplier holds onto a container, the less often the container is utilized (turnover) within the supply chain. The lower turnover demands a larger number of containers for the supply chain pool. Ultimately, Ford pays the leasing costs as a function of container pool size. The misaligned incentives have caused Ford and their component suppliers difficulties in the past. One train of thought was to dictate and constrain the component suppliers to the number of containers and to the length of time that they may retain containers. Dictating and constraining any process ultimately results in deadweight loss. The Ford core team along with the Durable Container Provider reviewed this policy to determine a mutually beneficial scenario for all stakeholders, including the two hundred and seventy component suppliers. The resulting policy was that the component suppliers would receive containers equal to five days worth of production at no cost to the component supplier, while Ford pays the daily lease fees. If the component suppliers need containers greater than five days worth of production, then the supplier must pay a small daily fee per container. Similar to the supermarket industry - Section 3.1, the supplier fee encourages the component suppliers to turnover the container assets; but if the supplier receives value-added from the containers being a part of their Work-In-Progress then let the supplier pay for the containers at a fair market price. The revenues generated from the supplier fees could be used by Ford to offset container lease costs or purchase more containers to increase the pool size; thus, if suppliers hold onto containers resulting in a larger pool size, the daily supplier fees would self fund the container pool size. Recognizing the fact that suppliers may need containers for longer periods of times and charging them appropriately allows Ford and their component suppliers to cooperate in harmony with the financial and process market forces. Working as partners, the Ford core team and the Durable Container Provider developed a strategy to complement market forces instead of resisting market forces.

The core team also envisioned a futuristic incentive strategy for the FLC/FSC container process. The five "free" days worth of production containers that component suppliers receive is constraining and wasteful. The "free" days means no cost to the component suppliers, while the Ford assembly plants pay the actual leasing fees for their component suppliers. The number of five days was determined years ago as an across the board number for component suppliers in fourteen different countries. The number is a function of the safety stock to transport empty containers from assembly plants to the awaiting component suppliers. This number has never been scientifically evaluated with supply chain principles. At one time in the internship, the student was going to apply MIT supply chain logistics and find the optimal number of reserve days which could have been converted to "free" days. Instead of an engineering logistics solution, an organizational process solution was developed to resolve the "free" days issue. Every year Ford requests that their suppliers become more efficient and reduce their prices, thus reducing the overall supply chain costs. Unfortunately, these discussions can become a tug-pull negotiation instead of a mutually beneficial negotiation. In May 2002, Ford will roll out a new three-year contract with a new Durable Container Provider. This launch alone will require a great deal of energy considering there are two hundred and seventy component suppliers in fourteen countries. After the FLC/FSC Durable Container Provider launch, Ford will offer the component suppliers a shared cost saving opportunity for those suppliers that can operate with less than five days worth of containers. The smaller amount of containers that a component supplier requires results in a smaller container pool, which reduces Ford's container leasing costs. Ford and their suppliers could remove a constraint and deadweight loss from the supply chain in synergy with their yearly objectives. More importantly the organizational process solution allowed Ford and their component supplier a mutually beneficial cost savings opportunity that encourages the stakeholders to participate.

4.2 Visibility and Traceability – the Tools for Success

Visibility in the FXC container process is the knowledge of container locations, while traceability is the knowledge of container movements. The existing contract provided container locations and movements information that was two weeks old. The container requests were very volatile and were filled from a volatile supply at the Empty Pallet Compounds. As container requests were received, the empty containers would be shipped. The Durable Container Provider would try to source containers from the closest locations, but occasionally containers would travel further distances. As the containers were in transit, the Durable Container Provider had very little knowledge of the container locations. In addition, after the containers reached their locations, the information would take at least two weeks of processing before the Durable Container Provider would have useful container location information. The information delay made it very difficult to rebalance the containers across Europe. Containers that are in the wrong place at the wrong time would affect container quantities and safety stocks throughout Europe. Unfortunately, durable container mismanagement resulted in durable container shortages for the component suppliers who would use alternate packaging, mostly expendable containers, since the cost of a Ford European assembly plant stoppage is $15,000 per minute. The inability to make active empty container sourcing decisions hindered Ford and the Durable Container Provider. In addition, process failures (container shortages) and the lack of knowledge where the containers actually were in the supply chain resulted in the component suppliers' lack of trust and confidence in the ordering process from the Durable Container Provider. Component suppliers would compensate their lack of trust and confidence by over ordering, which resulted in higher ordering volatility from the Empty Pallet Compounds.

> "In reinforcing processes such as the Pygmalion effect, a small change builds on itself. Whatever movement occurs is amplified, producing more movement in the same direction. A small action snowballs, with more and more and still more of the same, resembling compounding interest. (referring to a snowball rolling down a hill growing larger and larger) Some reinforcing (amplifying) processes are "vicious cycles," in which things start off badly and grow worse. The "gas crisis" was a classic example. Word that gasoline was becoming scarce set off a spate of trips to the local service station, to fill up. Once people started seeing lines of cars, they were convinced that the crisis was here.

Panic and hoarding then set in. Before long, everyone was "topping off" their tanks when they were only one-quarter empty, lest they be caught when the pumps went dry. A run on a bank is another example, as are escalation structures such as the arms race or price wars."[4]

"Folk wisdom speaks of reinforcing loops in terms such as "snowball effect," "bandwagon effect," or "vicious circle," and in phrases describing particular systems: "the rich get richer and the poor get poorer." In business, we know that "momentum is everything," in building confidence in a new product or within a fledgling organization. We also know about reinforcing spirals running the wrong way. "The rats are jumping ship" suggests a situation where, as soon as a few people lose confidence, their defection will cause others to defect in a vicious spiral of eroding confidence. Word of mouth can easily work in reverse, and (as occurred with contaminated over-the-counter drugs) produce marketplace disaster."[5]

"Delays, when the effect of one variable on another takes time, constitute the third basic building block for a system language. Virtually all feedback processes have some form of delay. But often the delays are either unrecognized or not well understood. This can result in "overshoot," going further than needed to achieve a desired result. The delay between eating and feeling full has been the nemesis of a happy diner; we don't yet feel full when we should stop eating, so we keep going until we are overstuffed."[6]

"Unrecognized delays can also lead to instability and breakdown, especially when they are long. Adjusting the shower temperature, for instance, is far more difficult when there is a ten-second delay before the water temperature adjusts, then when the delay takes only a second or two. During the ten seconds after you turn up the heat, the water remains cold. You receive no response to your action; so you *perceive* that your act has

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[4] Senge, Peter M., "The Fifth Discipline," The Art & Practice of The Learning Organization, *Doubleday,* New York, New York, (1990). Chapter 5 – A Shift of Mind, p. 81.
[5] Senge, Peter M., "The Fifth Discipline," The Art & Practice of The Learning Organization, *Doubleday*, New York, New York, (1990). Chapter 5 – A Shift of Mind, p. 83.
[6] Senge, Peter M., "The Fifth Discipline," The Art & Practice of The Learning Organization, *Doubleday*, New York, New York, (1990). Chapter 5 – A Shift of Mind, p 89.

had no effect. You respond by continuing to turn up the heat. When the hot water finally arrives, a 190-degree Fahrenheit (88-degree Celsius) water gusher erupts from the faucet. You jump out and turn it back; and, after another delay, it's frigid again. On and on you go, through the balancing loop process. Each cycle of adjustments compensates somewhat for the cycle before."[7]

"The more aggressive you are in your behavior – the more drastically you turn the knobs – the longer it will take to reach the right temperature. That's one of the lessons of balancing loops with delays: that aggressive action often produces exactly the opposite of what is intended. It produces instability and oscillation, instead of moving you more quickly toward the goal."[8]

After reviewing the existing contract and understanding the dynamic behavior of the process, the core team benchmarked the durable container processes of other automotive manufacturers and other industries. The core team was searching for more than financial and logistics data. The core team wanted to understand other industries' dynamics. They determined that visibility and traceability were the tools for a successful process. Benchmarking the auto industry and other industries revealed inexpensive information technologies (internet) were attainable along with robust processes. With the opportunity to rewrite a new specification and contract, the core team decided to request active twenty-four hour, seven-days a week visibility and traceability of all FXC containers.

The durable container process was determined to be lacking costing visibility. Ford Motor Company needed more than a supplier for the durable container process, Ford Motor Company needed a partner with open book finances and costing visibility. Ford has a vested interest for all stakeholders to operate profitably and efficiently. For any process to be a self-reinforcing and efficient, all stakeholders need visibility to total cost and activity-based costing, because all stakeholders need visibility to continuously improve their Best-In-Class service.

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[7] Senge, Peter M., "The Fifth Discipline," The Art & Practice of The Learning Organization, *Doubleday*, New York, New York, (1990). Chapter 5 – A Shift of Mind, p 89-90.
[8] Senge, Peter M., "The Fifth Discipline," The Art & Practice of The Learning Organization, *Doubleday*, New York, New York, (1990). Chapter 5 – A Shift of Mind, p. 91.

"Each cost centers needs:

1. A clear definition of it boundaries,
2. An estimate of the time period to accomplish measurable units of output, and
3. An understanding of the cost drivers that explain variation in costs (if any) with variation in the activity level in the cost center."[9]

"Activity-based Management"

"The demand for more accurate and relevant management accounting information has led to the development of *activity-based management.* Activity-based management is a systemwide, integrated approach that focuses management's attention on activities with the objective of improving customer value and the resulting profit. Activity-based management emphasizes *activity-based costing* (ABC) and *process value analysis.* Activity-based costing improves the accuracy of assigning costs by first tracing costs to activities and then to the products or customers that consume these activities. Process value analysis, on the other hand, emphasizes activity analysis, trying to determine why activities are performed and how well they performed. The objective is to find ways to perform necessary activities more efficiently and to eliminate those that do not create customer value. Peter Drucker, internationally respected management guru, points out the growing importance of activity-based costing (management):"[10]

"Traditional cost accounting in manufacturing does not record the cost of nonproducing such as the cost of faulty quality, or of a machine being out of order, or of needed parts not being on hand. Yet these unrecorded and uncontrolled costs in some plants run as high as the costs that traditional accounting does record. By contrast, a new method of cost accounting developed in the last ten years-called "activity-based" accounting record all costs. And it relates them, as traditional accounting cannot, to value-added. Within

[9] Johnson, H. Thomas; Kaplan, Robert S., Relevance Lost, "The Rise and Fall of Management Accounting," *Harvard Business School Press*, Boston, Massachusetts, (1987), p. 230.
[10] Hansen/Mowen, "Management Accounting," *South-Western College Publishing*, Cincinnati, Ohio, (1997), p.13.

the next 10 years it should be in general use, and then we will have operational control in manufacturing."[11]

"Activity-based management is the heart of the contemporary management accounting system. If Peter Drucker is correct in his viewpoint, the study of contemporary management is crucial. Accordingly, the activity-based management model is strongly emphasized. However, at the same time traditional management accounting systems are not ignored--nor should they be. For some settings, traditional systems continue to work well and are much cheaper to use. Additionally, the transition from traditional management accounting to activity-based management accounting is not instantaneous. Time is required for firms to adopt new procedures. Furthermore, as new procedures are placed in the crucible of actual experience, we can expect more modifications."[12]

4.3 Accountability

Proper accountability will reinforce the proper behavior. Within the existing contract, Ford Motor Company paid for many process failures, which added a significant amount to the overall costs. Occasionally, Ford was the cause for process failures, but most often Ford was not the cause of process failures, even though Ford financially paid for the failures. The existing contract did not promote the stakeholders to remove the inefficient processes and failures. It is in all stakeholders' best interest to work as a functional team and reduce overall costs.

"No group ever becomes a team until it can hold itself accountable as a team. Like common purpose and approach, mutual accountability is a stiff test. Think, for example, about the subtle but critical difference between "the boss holds me accountable" and "we hold ourselves accountable." The first case can lead to the second; but without the second, there can be no team."[13]

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[11] Peter F. Drucker, "We Need to Measure, Not Count," *The Wall Street Journal*, (13 April 1993), p. A14.
[12] Hansen/Mowen, "Management Accounting," *South-Western College Publishing,* Cincinnati, Ohio, (1997), p. 14.
[13] Ancona; Kochan; Scully; Van Maanen; Westney, "Organizational Behavior & Processes," *South-Western College Publishing*, Cincinnati, Ohio, (1999), p. M6-31.

The core team envisioned a new process where the Durable Container Provider would champion the accountability for all stakeholders. This is only the first step. The second step would come through proper documentation of process failures with the proper stakeholder held accountable. No stakeholder will pay for any failure, unless there is proper documentation. If the Durable Container Provider cannot provide documentation, then the Durable Container Provider is financially obligated for the failure. The Durable Container Provider is the process-managing stakeholder, not Ford Motor Company, not the component suppliers, and not the Lead Logistics Partner. All stakeholders are functional team players with the Durable Container Provider acting as the boss holding the team players accountable.

Active container information would allow the details of the container process to be fully visible and failures would be avoided. If failures do occur, visibility of the process would allow the stakeholders to act like team players and hold themselves accountable. The existing two-week information delay hinders proper accountability. Again, inexpensive information technology was vital for a new and improved durable container process.

4.4 Robust and Stable Process

Ford Motor Company envisioned a new robust and stable process. A robust service can absorb disruptions in the process without resulting in expendable containers (failures). A stable process where the stakeholders understand their link in the supply chain and the container process would experience very few disruptions. The core team benchmarked other industries that handled higher volumes, shorter cycle times, volatile demand and supply while delivering a robust and stable container process. The main elements of a robust and stable process were simple, disciplined methods where the stakeholders fully understood their role in the supply chain supplemented by active container information. The core team weighted the choice heavily towards the Durable Container Providers' proposed customer service, controlled processes, and information technologies.

4.5 Quantifiable Specification

Ford Motor Company invited four suppliers to bid on the Durable Container Provider Specification. Ford needed a champion of a robust and visible (container and financial) service.

It was in everyone's best interest to have a flexible specification so that the four potential suppliers could develop their best service for Ford Motor Company. In addition, it was in everyone's best interest to have a clear quantifiable specification. If a supplier misunderstood the requested service, they may find the service unprofitable, which is in no stakeholders' interest. In addition, all stakeholders must have clear definable roles, responsibilities, and goals.

The specification format had been left open to allow flexibility to individual preferences; however, the following points should be met:

- Needs to be measurable.
- Ability to administer efficiently.
- Accountability for cost.
- Encourages the right behavior by all stakeholders.
- Drives lowest total cost.
- Drives Best-In-Class process.
- Encourages asset utilization.

Chapter 5: Level the Playing Field

The core team recognized that the four quotations submitted by the potential Durable Container Providers all had unique features and service levels. In addition, the core team had to determine the features that were value added and cost effective. Chapter 5 demonstrates the core teams' evaluation of the quotations.

5.1 Analysis of Quotation

Ford collected the sealed bids and evaluated the four quotations for financial and process content. Within the evaluations, discrepancies were determined and adjusted so that all four suppliers were properly represented. Ford asked the suppliers for a variety of clarifications via e-mail, phone, and fax. Ford assembled a cross-functional team of fourteen engineers, accountants, supervisors, and managers. The cross-functional team represented manufacturing, finance, and engineering who all had a variety of stakeholder interests. Even though a diverse team would require more time and energy to agree on which provider to sign a contract together, Ford valued the diverse resource knowledge and contribution as due diligence in making the optimal decision. For a few days, the core team reviewed the quotations, clarified issues, and prepared points of interest for the cross-functional team. At the same time, the four potential Durable Container Providers prepared for a two-hour presentation of their quotation. Ford had asked the Durable Container Providers to cover the thirty-one topics of the Appendix C: DCP Presentation Format. The core team chose these thirty-one topics based on the necessity to deliver a Best-In-Class container leasing service. The suppliers were given simple instructions to include these topics in the quotation presentation. The topics were weighted with the most influential topics for Best-In-Class receiving the most weight. Appendix D: DCP Evaluation Form is a copy of the original, except the weighted points are removed.

The existing Durable Container Provider had purchased containers for the Ford pool and Ford was responsible to purchase the containers back at the termination of the contract. The container valuation is to be finalized by the accounting departments. Instead of Ford purchasing them directly from the existing Durable Container Provider, Ford offered the three other potential Durable Container Providers the opportunity to purchase them from the incumbent Durable Container Provider. The containers were approximately five years old and had an expected life span of ten years. In addition, these existing used containers were much less expensive to purchase than new containers. All three potential Durable Containers Providers opted for the inexpensive used containers rather than new containers.

The specification was open-ended to encourage creative quotations, but at the same time the specification was all-inclusive and comprehensive. The core team received only a few requests for clarification. One example of a clarification pertained to who was responsible for cleaning the containers at the commencement of the contract. The containers were on the incumbent Durable Container Provider's books as assets and the incumbent treated these containers as their property. In addition, the incumbent labeled the containers as their property with stickers and permanently scribed their name into the containers. Ford agreed to purchase the containers if the incumbent did not receive the new contract. Ford never agreed to purchase containers with labels and scribes. Ford would only purchase containers that were completely clean without labels or scribes. Ford deemed any container labeled as property of another company as unacceptable for purchase. In addition, Ford would not insist that any potential Durable Container Provider purchase any container in any condition that Ford deems unacceptable. With this fact clarified, Ford removed all cleaning and initial handling costs from the quotations to level the playing field.

The strategy of why Ford would want to buy containers at the end of a lease was thoroughly evaluated. The existing contract was such that the incumbent would sell the containers to Ford or another third party at the termination of the leasing contract. The core team had to address all supply chain circumstances, including the possibility that the used containers would not be purchased. The production rate for new containers is approximately ten thousand containers per month. The existing FLC/FSC pool was approximately 230,000 containers. If new containers were purchased, instead of used containers, it would take approximately two years to completely fill the supply chain pool. Alternative packaging, such as expendable containers, would cost Ford €45.18 ($40.21) per occurrence. With container movements of 2.7 million per year, the impact to the supply chain logistics both financially and operationally would be enormous. In addition, the FLC/FSC container is extremely versatile and cost effective for automotive components, and the FLC/FSC is expected to be an integral part of the Ford supply chain for many years to come. With the disastrous impact if FLC/FSC containers were not available along with the versatility and cost effectiveness of the FLC/FSC containers, Ford determined is was a strategic advantage to have full access to the FLC/FSC containers at the termination of the new three-year leasing contract.

Lastly, the quotations had a variety of costs applied in different time frames. For example, three of four quotations had launch costs. In addition, services would be purchased throughout the three-year contract. The core team with the assistance of the manufacturing controller's office evaluated the quotations with a cash flow spreadsheet using the Ford cost of capital. The resultant net present value of the quotations represented a total cost approach for the three-year contract.

5.2. Cross-Functional Team Statistical Evaluation

The four potential Durable Container Providers were asked to present their quotations in a two-hour presentation, which was to include the topics of Appendix D: DCP Evaluation Form. The core team collected and compiled the cross-functional team ratings. Ford recognized the scores were subjective and treated them appropriately. The scores were for guidance purposes only in the evaluations. Ford reviewed the individual scores and ranking per question, topic, and average overall score. Also, Ford reviewed closely the average score and standard deviation per potential Durable Container Provider. The standard deviations allowed Ford to understand the volatility of scores per supplier from the evaluators. Of course, a small standard deviation meant the evaluators ranked similarly while a large standard deviation meant the evaluators ranked dissimilarly. The signal-to-noise ratio[14] (average score divided by standard deviation) provided further insight into the four potential Durable Container Providers' proposed services. The higher the signal-to-noise ratio, the more confidence the cross-functional team had in the subjective score. The financial net present value (NPV) of the three-year service contract for each Durable Container Provider was determined. One of the most powerful statistical evaluation methods for each Durable Container Provider was the net present value of their

[14] Vining, G. Geoffrey, "Statistical Methods for Engineers," *Brooks/Cole Publishing Company,* Pacific Grove, California, (1998), p. 430.

service divided by their average score. The lower the ratio of net present value per average score, the better value for the service.

5.3 Forecasting Service

In the pursuit of leveling the playing field, the cross-functional team did some predictions of the potential savings each company would deliver. The evaluation scores and sequential debriefs demonstrated that some of the more expensive services offered Ford more potential internal savings. Ford's objectives included overall efficiency and total supply chain cost. The core team had to quantify the different services. For example, a substantial savings would be obtained if the Durable Container Provider could manage the container assets more efficiently. If the average container would travel in the supply chain one less day (cycle day), the number of container assets could be reduced. The FLC/FSC container pool required 12,394 movements per day. For each day that the Durable Container Provider could reduce the average cycle time, 12,394 containers could be reduced from the Ford FLC/FSC pool. New FLC and FSC containers cost approximately €200 ($178) each, while used FLC and FSC containers cost approximately €100 ($89) each. New FLC and FSC containers are amortized ten years straight line, while used FLC and FSC containers are amortized five years straight line. Regardless of the container's age, the annual amortized cost is approximately €20 ($17.80) per FLC or FSC. The Durable Container Provider will pass the amortization costs onto Ford as an integral part of the lease price. The annual cost savings to Ford for each day the Durable Container Provider operates the FLC/FSC pool more efficiently is €247,880 or $220,613 (€20 * 12,394, daily container movements). The cross-functional team had predictions for what each Durable Container Provider could deliver in service level including cycle time reduction. The predictions were compiled and applied in the sensitivity analysis, see Section 5.4 Sensitivity Analysis. The actual data is confidential but below is sample of fictional data, which in no manner represents the actual confidential data. The cross-functional team believed that the Durable Container Provider would have to demonstrate that the containers were not utilized for nearly a year including a model launch before the containers would be removed from the pool. Expected increases of container movements for the Ford pool, and the anticipation that Ford would share containers with other divisions within Ford Motor Company, like Jaguar and Land Rover, would result in cost avoidance from purchasing new containers if the Durable Container Provider could reduce the cycle time.

As found in Table 5.3.A, the cross-functional team predicted performance probabilities of the four Durable Container Providers for cycle times of 19, 17, 15, and 13 days. The evaluators where asked to predict the success probabilities of each DCP obtaining the cycle times. Table 5.3.A demonstrates three evaluators' predicted probabilities along with the predicted average for each DCP. The cumulative probability of each DCP was applied to the cost savings value of each cycle time. The current FLC/FSC process operates at 19 working days cycle time and has no cost savings, while the cycle time of 17, 15, and 13 days would have annual cost savings to Ford Motor Company in amount of €495,760, €991,520, and €1,487,280 ($441,226, $882,453, and $1,323,679) respectively. For example, DCP A received the following cumulative probabilities of 100%, 58.33%, 26.67%, and 11.67% for cycle times of 19, 17, 15, and 13 respectively. The predicted cost savings would be €479,235.

Payout Calculation:
(1.0 – 0.5833) * €0 + (0.5833 – 0.2667) * €495,760 + (0.2667 – 0.1167) * €991,520 + (0.1167 – 0.0) * €1,487,280 = €479,235

DCP A Cumulative Probability Distribution:
(1.0 – 0.5833) = 41.67%, (0.5833 – 0.2667) = 31.67%, (0.2667 – 0.1167) = 15.00%, (0.1167 – 0.0) = 11.67%

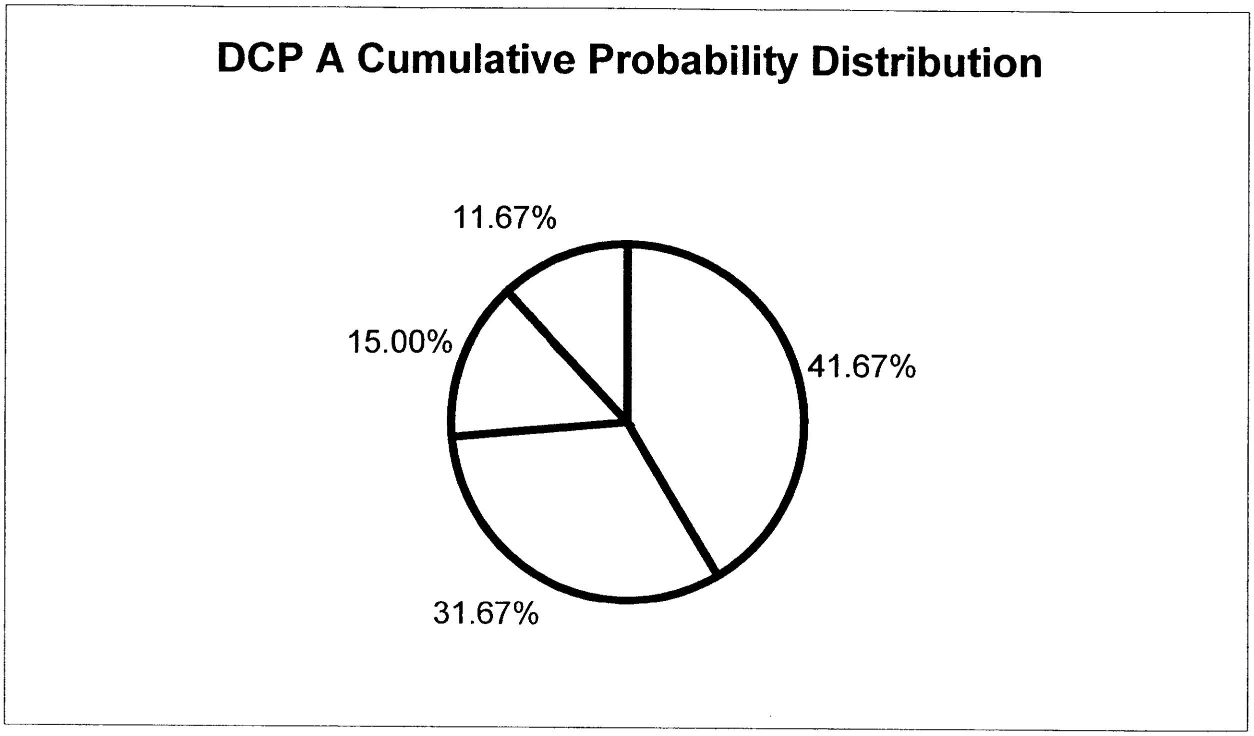

DCP A Cumulative Probability Distribution
11.67%
15.00%
41.67%
31.67%

Table 5.3.A

Potential Durable Container Providers

Evaluator 1 Predictions

Cycle Time in Working Days	A	B	C	D
19	100	100	100	100
17	65	90	65	95
15	40	70	30	75
13	25	40	20	45

Evaluator 2 Predictions

Cycle Time in Working Days	A	B	C	D
19	100	100	100	100
17	50	75	60	80
15	20	60	50	70
13	0	25	10	30

Evaluator 3 Predictions

Cycle Time in Working Days	A	B	C	D
19	100	100	100	100
17	60	85	75	90
15	20	70	30	75
13	10	40	20	50

Average Scores of Evaluators

Overall % Averages	A	B	C	D
19	100%	100%	100%	100%
17	58.33%	83.33%	66.67%	88.33%
15	26.67%	66.67%	36.67%	73.33%
13	11.67%	35.00%	16.67%	41.67%

Average Daily Container Movements		12,394
Amortize per Container	€	20.00
Annual Ford Savings per day of Cycle Time reduction	€	247,880

Cycle Time in Working Days		Annual Savings per Cycle Time
19	€	-
17	€	495,760
15	€	991,520
13	€	1,487,280

Predicted Annual Savings per DCP			
A	B	C	D
€ 479,235	€ 917,156	€ 594,912	€ 1,008,045

5.4 Sensitivity Analysis

The core team along with the manufacturer controller's office prepared a sensitivity analysis utilizing costs from the Durable Container Providers' quotations and internal costs to operate the FLC/FSC process. Costs would be occurred during different time periods throughout the three-year contract; therefore, a cash flow spreadsheet was prepared to determine net present value of the whole contract at commencement. Some of the internal costs included Ford's predicted failures and successes in driving out inefficiencies. The Durable Container Provider was going to champion accountability and hold the appropriate stakeholders, including Ford, accountable for their failures. Ford expects to be held accountable for its inability to operate on the efficient frontier. These occasional focus lapses would be greater during model launches and less during more stable occasions. In addition, the variety of proposed services from the four Durable Container Providers would require a variety of Ford manpower to support the services. These service variations and the Ford manpower to support were quantified and applied in the cash flow spreadsheet.

Chapter 6: Durable Container Logistics

This chapter evaluates the supply logistics to develop a mathematical model of the Ford of Europe FLC/FSC process. Data is collected in *Microsoft* "Excel" format, because the optimization software, which will be presented in Chapter 7, requires the "Excel" format. The Base Stock Model including cycle stock and safety stock will be determined along with the leadtimes from country to country. Most importantly, Ford of Europe has logistics problems where containers are not in the correct region when needed. This logistics problem is also known as the rebalancing issue. Within this chapter, the rebalancing issue will be quantified and then utilized in Chapter 7 as the working parameters (operation constraints).

6.1 Supply Chain Model

Date was collected for a twelve-month period from June 2000 through May 2001. Data collected included empty container demand by the component suppliers, vehicle assembly production, and FLC/FSC containers per vehicle model. The logistics model represents the Ford European FLC/FSC container pool utilizing the Base Stock Model. Further information pertaining to the Base Stock Model can be found in Appendix A: Inventory Basics and Simchi-Levi, Kaminsky, Simchi-Levi.[15] As described in Chapter 2, the FLC/FSC process incorporates periodic review, r.

The Base Stock Model formula for a periodic review:

$$\text{Expected Inventory} = \text{cycle stock} + \text{safety stock}$$

$$E(I) = \text{cycle stock} + z * \sigma * \sqrt{(r + L)}$$

E(I), Expected Inventory

z, standardized variant

σ, standard deviation of leadtime demand

r, order interval time

L, replenishment leadtime

[15] Simchi-Levi, David; Kaminsky, Philip; Simchi-Levi, Edith, "Designing and Managing the Supply Chain," *McGraw-Hill Higher Education,* Boston, Massachusetts, (2000), p. 69-75.

The component suppliers submit a daily request to the Durable Container Provider; therefore, a periodic review was utilized in the logistics model. The average daily demand for the FXC process is 12,394 containers. As described in Chapter 2, an order from the component supplier will take up to three days to process by the Durable Container Provider who in turns notifies the Lead Logistics Partner that an order is ready for delivery. Within two days of receipt of the notification from the Durable Container Provider, the Lead Logistics Partner will schedule a truck to pick up empty containers from an Empty Pallet Compound and haul them to the component supplier. The order interval time (r) is equal to five days. The replenishment leadtime (L) is a function of the distance from the Empty Pallet Compound to the component supplier. The optimal outbound time or replenishment leadtime (L) is 2.00 days. For further information about transportation see Sections 6.2 and 7.2.

6.1.1 Cycle Stock

The student used the average daily demand of containers in the pool to determine the cycle stock for the FLC/FSC process. The average daily demand for the twelve-month period was calculated as 12,394. As described in the Chapter 2 Durable Containers and Process, the component suppliers carry five days worth of usage to maintain their Work-In-Process. The Ford assembly plants typically hold about three days worth of inventory as Work-In-Process. The total Work-In-Process Inventory was estimated at 98,148 containers as shown in Table 6.1.1.A.

Table 6.1.1.A

Ford Demand Jun-00 through May-01, Component Suppliers to ASSEMBLY PLANTS
Average per Day for Europe

	FORD ASSEMBLY PLANTS						
Component Suppliers	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	14.18	178.30	0.00	44.22	309.81	27.64	186.75
France	17.48	624.83	24.62	40.01	678.88	126.35	388.94
Hungary	4.02	103.78	1.08	8.66	54.44	2.44	27.67
Italy	39.39	184.80	10.13	97.87	103.16	23.84	64.74
Netherlands	0.07	67.41	0.03	0.00	23.44	5.28	13.06
Poland	0.00	21.17	0.00	0.00	2.05	0.99	44.55
Portugal	4.57	21.69	1.84	9.85	22.09	2.10	36.36
Slovakia	0.00	5.15	0.00	0.00	2.49	0.00	1.20
Sweden	0.00	0.00	0.00	0.00	14.16	0.00	8.62
Switzerland	0.00	16.21	0.00	0.00	0.14	0.00	0.00
Belgium	0.46	61.47	34.58	2.29	326.09	0.00	40.70
Germany	148.97	845.89	0.00	358.06	794.56	57.65	436.84
United Kingdom	232.42	603.64	66.22	391.02	1,064.58	183.32	473.44
Spain	92.58	531.05	25.18	241.36	611.05	84.25	973.31
Average per Day	12,393.54						

Work-In-Process Inventory

Days of WIP	8
Average per Day	12,393.54
Work-In-Process	**99,148**

The inbound transit inventory calculation was determined by location of component suppliers and their respective average daily usage multiplied by the Ford Transit Times per country. For example all Czech Republic components suppliers use an average of 14.18 FLC/FSC containers per day for their components required by the Dagenham Assembly Plant (Table 6.1.1.A). According to the Ford Logistics Group, the average transit time from the Czech Republic to Dagenham is 9 days (Table 6.1.1.B). The Total Inbound Transit Inventory was determined to be 40,708 containers. (Table 6.1.1.B). The average inbound container requires 3.28 days of transit time (40,708/12,394 = 3.28 days).

Table 6.1.1.B

Ford Transit Times

	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	9	5	8	5	5	10	8
France	4	4	5	3	3	4	4
Hungary	5	5	6	5	5	5	8
Italy	4	3	5.5	3	3	4	4
Netherlands	3	1	5.5	1	1	4	3
Poland	8	6	9	6	6	9	8
Portugal	5	5	5	5	5	4	2
Slovakia	9	5	8	5	5	10	8
Sweden	5	6	5	6	6	5.5	6
Switzerland	5	6	6	2	1	5	5
Belgium	2	4	4	1	1	3	3
Germany	3	5.5	5.5	1	1	3	3
United Kingdom	1	1.5	1.5	3	3	0.8	5
Spain	5	5.5	5.5	4	4	6	1

Inbound Inventory from Componet Suppliers to ASSEMBLY PLANTS

	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	127.65	891.50	0.00	221.12	1,549.05	276.40	1,493.97
France	69.93	2,499.31	123.08	120.04	2,036.64	505.41	1,555.76
Hungary	20.09	518.91	6.51	43.30	272.21	12.20	221.37
Italy	157.57	554.40	55.69	293.61	309.49	95.36	258.95
Netherlands	0.21	67.41	0.15	0.00	23.44	21.10	39.18
Poland	0.04	127.03	0.00	0.00	12.27	8.92	356.39
Portugal	22.86	108.45	9.22	49.23	110.45	8.39	72.72
Slovakia	0.00	25.74	0.00	0.00	12.45	0.00	9.58
Sweden	0.00	0.00	0.00	0.00	84.97	0.00	51.69
Switzerland	0.00	97.25	0.00	0.00	0.14	0.00	0.00
Belgium	0.93	245.87	138.34	2.29	326.09	0.00	122.11
Germany	446.91	4,652.39	0.00	358.06	794.56	172.94	1,310.51
United Kingdom	232.42	905.46	99.33	1,173.07	3,193.73	146.65	2,367.21
Spain	462.92	2,920.78	138.51	965.45	2,444.22	505.47	973.31
Total Inbound Inventory	**40,708**						

The Optimal Outbound Transit Inventory (returning empties to the component suppliers) calculation was determined using the optimal total cost solution as per Chapter 7: Simulation and Modeling. The optimal solution for daily container movements from assembly plants to component suppliers multiplied by the Ford Transit Times (Table 6.1.1.B) yielded the Optimal Outbound Transit Inventory of 24,789 containers (Table 6.1.1.C). The optimal days transit was 2.00 days of transit time. (24,789/12,394 = 2.00 days)

Table 6.1.1.C

Outbound Inventory from ASSEMBLY PLANTS to Component Suppliers, Optimal Solution

Average per Day for Europe

	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	0.00	0.00	0.00	0.00	746.33	0.00	0.00
France	0.00	895.77	0.00	0.00	1,005.13	0.00	0.00
Hungary	0.00	0.00	0.00	0.00	197.01	0.00	0.00
Italy	0.00	0.00	0.00	0.00	511.00	0.00	0.00
Netherlands	0.00	110.60	0.00	0.00	0.00	0.00	0.00
Poland	0.00	0.00	0.00	70.39	0.00	0.00	0.00
Portugal	0.00	0.00	0.00	0.00	0.00	0.00	99.92
Slovakia	0.00	0.00	0.00	0.00	8.60	0.00	0.00
Sweden	0.00	23.25	0.00	0.00	0.00	0.00	0.00
Switzerland	0.00	0.00	0.00	0.00	15.77	0.00	0.00
Belgium	0.00	478.85	0.00	0.00	0.00	0.00	0.00
Germany	0.00	0.00	0.00	1,120.99	1,523.09	0.00	0.00
United Kingdom	554.16	1,756.89	163.68	0.00	0.00	513.85	0.00
Spain	0.00	0.00	0.00	1.98	0.00	0.00	2,596.25
Average per Day for Europe	12,393.5						

Container Inventory

	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	0.00	0.00	0.00	0.00	3,731.64	0.00	0.00
France	0.00	3,583.07	0.00	0.00	3,015.38	0.00	0.00
Hungary	0.00	0.00	0.00	0.00	985.05	0.00	0.00
Italy	0.00	0.00	0.00	0.00	1,533.01	0.00	0.00
Netherlands	0.00	110.60	0.00	0.00	0.00	0.00	0.00
Poland	0.00	0.00	0.00	422.35	0.00	0.00	0.00
Portugal	0.00	0.00	0.00	0.00	0.00	0.00	199.85
Slovakia	0.00	0.00	0.00	0.00	43.02	0.00	0.00
Sweden	0.00	139.48	0.00	0.00	0.00	0.00	0.00
Switzerland	0.00	0.00	0.00	0.00	15.77	0.00	0.00
Belgium	0.00	1,915.40	0.00	0.00	0.00	0.00	0.00
Germany	0.00	0.00	0.00	1,120.99	1,523.09	0.00	0.00
United Kingdom	554.16	2,635.33	245.52	0.00	0.00	411.08	0.00
Spain	0.00	0.00	0.00	7.90	0.00	0.00	2,596.25
Optimal Outbound Inventory	**24,789**						

Cycle Stock is the summation of Work-In-Process, Inbound Inventory, and Optimal Outbound Inventory. It was estimated that the average cycle stock is 164,646 containers (Table 6.1.1.D).

Table 6.1.1.D

Cycle Stock = Work-In-Process + Inbound Inventory + Outbound Inventory

Work-In-Process	**99,148**
Total Inbound Inventory	**40,708**
Optimal Outbound Inventory	**24,789**
Cycle Stock	***164,646***

6.1.2 Safety Stock

"Safety Stock is the amount of inventory that a distributor needs to keep at the warehouse and in the pipeline to protect against deviations from the average demand during lead time."[16]

"Safety Stock for the system represents inventory that protects it against stockouts due to fluctuations in either demand or deliveries."[17]

"Service Level – α – is the probability of not stocking out during lead-time. 1 - α is the probability of stock out."[18]

Entry is the area $\Phi(z)$ under the standard normal curve from $-\infty$ to z.

Selected Percentiles

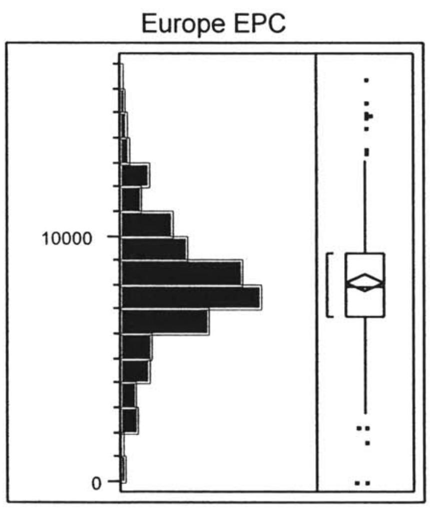
Cumulative probability $\Phi(z)$:	90%	95%	97.50%	98%	99%	99.50%	99.90%
z:	1.282	1.645	1.96	2.054	2.326	2.576	3.09

Where a service level of 98% probability of coverage (2% probability of stockout) equates to standardized variant, z of 2.054.[19]

[16] Simchi-Levi, David; Kaminsky, Philip; Simchi-Levi, Edith, "Designing and Managing the Supply Chain," McGraw-Hill Higher Education, Boston, Massachusetts, (2000), p. 52-53.
[17] Hopp, Wallace J.; Spearman, Mark L., "Factory Physics," McGraw-Hill Higher Education, New York, New York, (2001), p. 70.
[18] Simchi-Levi, David; Kaminsky, Philip; Simchi-Levi, Edith, "Designing and Managing the Supply Chain," *McGraw-Hill Higher Education,* Boston, Massachusetts, (2000), p. 52.
[19] Hopp, Wallace J.; Spearman, Mark L., "Factory Physics," *McGraw-Hill Higher Education,* New York, New York, (2001), p. 671.

Safety Stock is the number of extra items needed to assure a process does not incur shortages during normal operations. In the FXC process, the safety stock is the number of empty containers available at the Empty Pallet Compounds that could be shipped to the component suppliers. Also, the safety stock is a function of the production vehicles and FXCs per vehicle. As vehicles are assembled, FXCs filled with components become empty at production line side and then are delivered to the assembly plant's Empty Pallet Compound. During the twelve-month period at approximately 6 AM every morning, the number of FXCs was physically counted. The average amount of available containers at all Empty Pallet Compounds was 8,109. Diagram 6.1.2.A is a "Box and Whiskers" plot of all seven European Empty Pallet Compounds. The skewness of the plot is 0.127 with a CV (Coefficient of Variation of 0.32352 – mean divided by standard deviation). Using the Shapiro-Wilk W test, the daily number of FXCs at the Empty Pallet Compound was found to be normally distributed since $p > 0.05$.[20] Daily amounts at each Empty Pallet Compound can be found in Appendix E.

Diagram 6.1.2.A



Quantiles

maximum	100.0%	16449
	99.5%	16168
	97.5%	14033
	90.0%	11864
quartile	75.0%	9297
median	50.0%	7976
quartile	25.0%	6701
	10.0%	4652

[20] Best, Al M.; Obermiller, Daniel J., "JMP IN® Companion for G. Geoffrey Vining's Statistical Methods for Engineers," Duxbury Press, Pacific Grove, California, (1998).

	2.5%	2863
	0.5%	0
minimum	0.0%	0

Moments

Mean	8109.346
Std Dev	2623.576
Std Error Mean	162.707
Upper 95% Mean	8429.748
Lower 95% Mean	7788.944
N	260.000
Sum Weights	260.000

Test for Normality
Shapiro-Wilk W Test

W	Prob<W
0.975252	0.0527

Daily vehicle production was examined over the twelve-month period from June 2000 through May 2001. $\mathbf{X_{IL}}$ represents the daily vehicle production variance for each model **I** by country region **L** where it is produced (Table 6.1.2.A). $\mathbf{A_{IL}}$ represents the FXC container ratio sourcing for vehicle model **I** from component suppliers in country region **L**. Ford of Europe builds vehicles in three regions: Germany, Britain, and Spain. The component suppliers are located in four regions: Germany, Britain, Spain, and the 4^{th} region, representing all other European countries. The Durable Container Provider will organize the available containers (safety stocks) either by vehicle model or by region. Both safety stocks are functions of vehicle production variance. The safety stock organized for vehicle models has independent safety stocks for each vehicle model. The safety stock by region shares available containers within their respective region. The regional safety stock relies on communication and transportation flexibility within the region.

Table 6.1.2.A

Daily Vehicle Production Variance

	Var X_{IL}	German L=1	British L=2	Spanish L=3
Ka	I=1	0	0	646
Fiesta - German	I=2	3,092	0	0
Fiesta - British	I=3	0	4,017	0
Focus - German	I=4	9,335	0	0
Focus - Spanish	I=5	0	0	1,441
Mondeo	I=6	22,877	0	0
Transit - German	I=7	2,411	0	0
Transit - British	I=8	0	1,959	0
Escort	I=9	0	259	0

Average Daily Containers Model-Supplier Location	**A_{IL}**	German L=1	British L=2	Spanish L=3	Other L=4	**Ratio of FXC/vehicle** Subtotals
Ka	I=1	0.16	0.16	0.33	0.27	0.93
Fiesta - German	I=2	0.34	0.37	0.23	0.19	1.12
Fiesta - British	I=3	0.31	0.47	0.19	0.16	1.13
Focus - German	I=4	0.65	0.62	0.36	0.70	2.33
Focus - Spanish	I=5	0.41	0.41	0.84	0.67	2.33
Mondeo	I=6	0.52	0.34	0.30	0.70	1.86
Transit - German	I=7	0.57	0.38	0.34	0.77	2.06
Transit - British	I=8	0.23	0.74	0.34	0.76	2.06
Escort	I=9	0.21	0.40	0.15	0.23	1.00

6.1.2.1 Safety Stock by Model

Safety Stock as Base Stock Model

$$z * \sigma * \sqrt{(r + L)}$$

z, standardized variant

σ, standard deviation of leadtime demand

r, order interval time

L, replenishment leadtime

r = 5 days, L = 2 days

Sigma is determined by the square root of vehicle production variance (vehicle production standard deviation, $\sigma = \sqrt{\text{variance}}$) multiplied by the ratio of FXC per vehicle. For example a periodic review of 5.0 days to process a component supplier's order and optimal delivery from the Empty Pallet Compound of 2.00 days for Pan-Europe, the following safety stocks where determined for each model found in Table 6.1.2.1.A:

Table 6.1.2.1.A

$z * \sigma * \sqrt{(r + L)}$

1* sigma * (review period + Lead Time)^0.5

		German	British	Spanish	SS
Ka	I=1	0	0	62	62
Fiesta - German	I=2	165	0	0	165
Fiesta - British	I=3	0	190	0	190
Focus - German	I=4	596	0	0	596
Focus - Spanish	I=5	0	0	234	234
Mondeo	I=6	746	0	0	746
Transit - German	I=7	268	0	0	268
Transit - British	I=8	0	242	0	242
Escort	I=9	0	42	0	42
					2,546

	German	British	Spanish
Periodic Review Safety Stock			
	1,776	**474**	**297**
Safety Stock by Model	**2,546 (z = 1, r = 5.0, L = 2.00)**		

6.1.2.2 Safety Stock by Region

Vehicle production is concentrated in three regions: Germany (Genk, Cologne, Saarlouis), Britain (Dagenham, Halewood, Southampton), and Spain (Valencia). Most often component suppliers receive their containers from assembly plants in their region. Within this section, safety stocks by region are determined. The available containers at the Empty Pallet Compounds within a region determine the regional safety stock. A regional safety stock assumes containers are easily accessible within a region. The three German Empty Pallet Compounds are within 295 kilometers (184 miles) of each other. The three British Empty Pallet Compounds are within 365 kilometers (228 miles) of each other.

Var X_{IL} – variance of vehicle production corresponding to model **I** and assembly location **L**

A_{IL} – container ratio per model **I** and vehicle production location **L**

I – denotes models (1-9)

L – denotes region

L = 4 – denotes component suppliers not in any of the three vehicle production regions of German, Britain, or Spain (non-vehicle production region)

$$\text{I in region L, L}' = \text{L}$$

$$\text{Var (L inventory)} = \Sigma_I ((A_{IL} + A_{I4})^2 * \text{Var } X_{IL}) + \Sigma_I \Sigma_{L'} (A_{IL}{}^2 * \text{Var } X_{IL'})$$

The variance of containers in region L is a function of containers used in that region and those in the 4th region (non vehicle production region) multiplied by the vehicle production variances for that region plus the containers originating from that region for production in the other production regions. The values of $\mathbf{X_{IL}}$ and $\mathbf{A_{IL}}$ from Section 6.1.2 (Table 6.1.2.A) apply for the following calculations.

Table 6.1.2.2.A

L=1

$A_{IL}{}^2 * \text{Var } X_{IL'}$		**L'=2**	**L'=3**
Ka	I=1	0.00	17.39
Fiesta - German	I=2	0.00	0.00
Fiesta - British	I=3	374.33	0.00
Focus - German	I=4	0.00	0.00
Focus - Spanish	I=5	0.00	246.04
Mondeo	I=6	0.00	0.00
Transit - German	I=7	0.00	0.00
Transit - British	I=8	105.16	0.00
Escort	I=9	11.49	0.00
$\Sigma_I \Sigma_{L'} (A_{IL}{}^2 * \text{Var } X_{IL'})$		754.41	

Table 6.1.2.2.B

L=2

$A_{IL}{}^2 * \text{Var } X_{IL'}$		**L'=1**	**L'=3**
Ka	I=1	0.00	17.10
Fiesta - German	I=2	415.92	0.00
Fiesta - British	I=3	0.00	0.00
Focus - German	I=4	3,587.68	0.00
Focus - Spanish	I=5	0.00	241.84
Mondeo	I=6	2,717.90	0.00
Transit - German	I=7	351.35	0.00
Transit - British	I=8	0.00	0.00
Escort	I=9	0.00	0.00
$\Sigma_I \Sigma_{L'} (A_{IL}{}^2 * \text{Var } X_{IL'})$		7,331.78	

Table 6.1.2.2.C

L=3

$A_{IL}^2 * \text{Var } X_{IL'}$		**L'=1**	**L'=2**
Ka	I=1	0.00	0.00
Fiesta - German	I=2	158.47	0.00
Fiesta - British	I=3	0.00	143.69
Focus - German	I=4	1,182.00	0.00
Focus - Spanish	I=5	0.00	0.00
Mondeo	I=6	2,103.56	0.00
Transit - German	I=7	271.93	0.00
Transit - British	I=8	0.00	224.57
Escort	I=9	0.00	6.09
$\Sigma_I \Sigma_{L'} (A_{IL}^2 * \text{Var } X_{IL'})$		4,090.32	

Table 6.1.2.2.D

		German	British	Spanish
$(A_{IL} + A_{I4})^2 * \text{Var } X_{IL}$		L=1	L=2	L=3
Ka	I=1	0.00	0.00	232.31
Fiesta - German	I=2	856.02	0.00	0.00
Fiesta - British	I=3	0.00	1,633.25	0.00
Focus - German	I=4	17,205.14	0.00	0.00
Focus - Spanish	I=5	0.00	0.00	3,286.09
Mondeo	I=6	33,862.18	0.00	0.00
Transit - German	I=7	4,377.40	0.00	0.00
Transit - British	I=8	0.00	4,377.64	0.00
Escort	I=9	0.00	103.71	0.00
$\Sigma_I ((A_{IL} + A_{I4})^2 * \text{Var } X_{IL})$		56,300.74	6,114.61	3,518.40

Table 6.1.2.2.E

Variance of FXC Inventory per 'L' Region

German	British	Spanish
L=1	L=2	L=3
57,055	13,446	7,609
Total Variances	78,110	

Standard Deviation of FXC Inventory per 'L' Region

German	British	Spanish
L=1	L=2	L=3
239	116	87

Periodic Review Safety Stock

$$z * \sigma * \sqrt{(r + L)}$$

1* sigma * (review period + Lead Time)^0.5

German	British	Spanish
L=1	L=2	L=3
632	307	231
Regional Safety Stock	1,170 (z =1, r = 5.0, L = 2.00)	

There are only three production regions, German, British, and Spanish, as opposed to the nine model types (see Table 6.1.2.1.A). As per Section 6.1.2.1, if a Safety Stock by Model is utilized with a z =1, then 2,552 containers are necessary. A Regional Safety Stock allows containers to be shared within each region; thus smoothing out the effects of production variability and ultimately making more empty containers available for the awaiting component suppliers. The Regional Safety Stock with z = 1 is 1,170 containers, which is 54% smaller than a Safety Stock by Model.

6.1.2.3 Safety Stock Rightsizing

Safety stocks protect against process failures. The size of the safety stock, coverage against failure, is dependent upon z, standardized variant (safety factor). For z =1 (safety factor of 1), the probability of successful container coverage is 84.13% and the probability of failed container coverage is 15.87%. For z = 4, the probability of successful container coverage is 99.9968% and the probability of failed container coverage is 0.00317%. Further information on z, the safety factor, can be located in Section 6.1.2.

z	Probability of Coverage	Probability of Failure
1	84.13447%	15.86553%
2	97.72499%	2.27501%
3	99.86500%	0.13500%
4	99.99683%	0.00317%

The larger the safety stock the less likelihood of durable container failures, which result in expendable packaging (cardboard). For each extra durable container, Ford incurs an annual cost of €64.08. For each failure or expendable container, Ford incurs a cost €45.18 per occurrence. Ford needs to operate at the best safety stock level with respect to durable FXC and expendable container costs. The thesis performs both a computer optimization and the mathematical derivation to find the best safety stock. The optimization software utilized was "Solver" from *Frontline Systems* of Las Vegas, Nevada. The objective cell for "Solver" was to minimize the total cost within line 27 of Table 6.1.2.3.A located on the next page. Lines 4 –16 were based on data collected by the student. Lines 13 and 14 represent the safety stock for when z =1 for both the regional and model safety stock processes as described in Sections 6.1.2.1 and 6.1.2.2. Line 17 was calculated by multiplying the cost of a new FXC container by the cost of capital and the annual depreciation and summed with the annual real estate cost per container. Line 20 contains the z value, safety factor, where the optimization software "Solver" incrementally varies to find the lowest total cost of line 27. Line 21 contains the safety stock amount for both the regional and model safety stock processes. Line 21 is simply the product of z and its respective process from Line 20. Line 22 and 23 are the probabilities of coverage and failure for their respective z, safety factor. Line 25 - stockout cost is the product of line 4 - annual movements, line 23 - probability of no stock, and line 14 - cost per failure. Line 26 - safety stock cost is the product of line 17 - annual cost of new FXC and line 21 - safety stock in units. Line 27 is simply the sum of line 25 - stockout cost and line 26 - safety stock cost. Within line 29 are the annual occurrences of no stock, which is the product of line 4 annual container movements and line 23 probability of no stock. Lastly, line 30 is the daily occurrences of no stock, which is line 29 divided by the average annual working days of 216.4.

Table 6.1.2.3.A
Ford Motor Company
FLC/FSC Safety Stock Utilizing *'Solver'* Optimization

4	FLC/FSC Movements		2,694,654			
5	FLC New	€	200.00			
6	DCP Cost of Capital		10%			
7	Depreciation/Year For New FLC		10%			
8						
9	Cardboard Box	€	22.56			
10	Disposal per Box	€	2.08			
11	Repacking per Box	€	4.48	Safety Stock		
12	Forklift and Janitor Impact	€	5.67	z=1		
13	Inbound Freight Impact	€	10.38	Regional		1,170
14	Cost per Failure	€	45.18	By Model		2,546
15						
16	Annual Real Estate Cost per FLC	€	24.08			
17	Annual Cost of New FLC	€	64.08			
18						
19	**Regional**			**By Model**		
20	z		3.598366	z		3.375217
21	Safety Stock in Units		4,208	Safety Stock in Units		8,594
22	Probability of Stock		0.9998399	Probability of Stock		0.9996312
23	Probability of No Stock		0.0001601	Probability of No Stock		0.0003688
24						
25	Stock Out Cost	€	19,497	Stock Out Cost	€	44,903
26	Safety Stock Cost	€	269,666	Safety Stock Cost	€	550,692
27	Total Cost	€	289,163	Total Cost	€	595,595
28						
29	Annual Occurrences of no stock		432	Annual Occurrences of no stock		994
30	Average no stock per Day		1.99	Average no stock per Day		4.59

The rightsizing of safety stock with respect to number of containers and cost can also be performed mathematically.

N – Number of trials

Φ – Cumulative Probability

ϕ – Density Probability

X – Safety Stock (inventory level) = $z * \sigma$

z – Standardized Variant

σ - sigma, standard deviation of process

h - holding cost

p – penalty for failure

$$G(X) = N * (1 - \Phi(X/\sigma)) + zh$$

$$G(X') = pN * (-\phi(X/\sigma)/\sigma) + h$$

$$pN/\sigma * \phi(X/\sigma) = h$$

$$\phi(X/\sigma) = h\sigma/pN$$

$$X = \sigma * \phi^{-1}(h\sigma/pN)$$

$$\phi(z) = (1/\surd(2\pi)) * e^{(-z2/2)}$$

$$e^{(-z2/2)} = \surd(2\pi) * (h\sigma/pN)$$

$$-z^2/2 = \ln(\surd(2\pi) * (h\sigma/pN))$$

$$z^2 = -2 * \ln(\surd(2\pi) * (h\sigma/pN))$$

$$z = \surd(-2 * \ln(\surd(2\pi) * (h\sigma/pN)))$$

$$X = z * \sigma$$

6.2 Transportation

The Ford of Europe Transportation group coordinates nearly all logistics to and from the assembly plants. Annual transportation costs for Pan-Europe are over $300 million. The FLC/FSC reusable container process transportation costs are approximately $7 million. The logistics group will use a combination of Ford owned and outside contractor trucks. Inbound components and their respective containers are a function of customer vehicle demand. As vehicles are built to customer orders, containers are emptied based on automotive components per vehicle derivative. (Vehicle derivatives are the variety of options of the same vehicle model.) Empty containers are moved from the assembly line side to the Empty Pallet Compounds where they are collected and wait to be shipped back to component suppliers. As described in Chapter 2, the containers are interchangeable and do not need to return to the same inbound component supplier. The standard containers are mixed and shipped back to component supplier by the best (shortest length and lowest cost) route. The Durable Container Provider will notify the Ford Transportation group to deliver containers from the Empty Pallet Compound to a component supplier. The Ford Transportation group in conjunction with the Lead Logistics Partner will determine by what method the container will travel. The three most common methods are Pooling, One-for-One Milk Runs, and Pony Express, which are described in Sections 6.2.1, 6.2.2, and 6.2.3. The Durable Container Provider and the Lead Logistics Partner will choose which transportation method based on the lowest total cost (component inventory holding cost, transportation cost, durable container asset cost, etc.) This thesis optimized using the transportation pooling method (consolidated freight). The optimization results for the pooling shipping template are detailed in Chapter 7.

6.2.1 Transportation Pooling

Transportation pooling is the use of a common dock or warehouse by trucks and trailers. Transportation pooling is not to be confused with container pooling. Further information pertaining to container pooling may be found in Chapters 2 and 3.

When shipments are made from one location to the next they may travel via consolidated freight, which is usually the least expensive shipping method. Consolidated freight is also known as transportation pooling and is demonstrated in the following example. A logistics person will notify a carrier such as UPS to pick up a package. UPS will pick up the package and transport it to a local sorting hub (warehouse) where it is placed on a truck with many other packages traveling to the same location. The truck will not deliver directly to the actual destination; but instead the truck will travel to a sorting hub (warehouse) somewhere near the destination. The truck will be unloaded and the packages will be sorted into new truck routes determined by neighborhoods. The consolidated freight will usually have the longest leadtimes for delivery. For the European FXC container pool, consolidated freight was a very popular choice for transportation.

Cross-docking is a form of transportation pooling where there is one sorting warehouse and the inventory remains within the warehouse for less than 24 hours. Ford of Europe utilizes this technique for the United Kingdom / European continent route via their strategically located Dagenham, England facility.

> "Cross-docking is a strategy that Wal-Mart made famous. In this system, warehouses function as inventory coordination points rather than as inventory storage points. In typical cross-docking systems, goods arrive at warehouses from the manufacturer, are transferred to vehicles serving the retailers, and are delivered to the retailers as readily as possible. Goods spend very little time in storage at the warehouse – often less than 12 hours. This system limits inventory costs and decreases lead times by decreasing storage time."[21]

6.2.2 One-For-One Milk Runs

One-For-One Milk Runs are transportation routes where trucks travel dedicated routes from assembly plants to component suppliers on a routine basis. Trucks will leave an assembly plant with empty containers and travel to one or many component suppliers in the dedicated route. While at the component supplier, the truck will drop off the empty containers and pick up the same number of containers filled with automotive components. The route may be repeated as often as every hour or every few days. Theses routes are most popular when the assembly plant and component supplier are in close proximity of each other usually less than one thousand and five hundred kilometers. The distance 1,500 kilometers was determined as a function of freight (inbound and outbound) and supply chain inventory costs.

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[21] Simchi-Levi, David; Kaminsky, Philip; Simchi-Levi, Edith, "Designing and Managing the Supply Chain," *McGraw-Hill Higher Education,* Boston, Massachusetts, (2000), p. 113-114.

6.2.3 Pony Express

In the 19th century, the Pony Express would deliver packages across the western United States. Each rider and his pony would be designated two posts, a start and a stop post. There would be many posts across the western United States with riders and ponies at these locations, making a long supply chain. At each post, the riders meet and trade packages then travel back the route he came; hence the packages would travel across the country while each rider and pony would travel limited distances between posts.

The Ford Pony Express works in a similar fashion to its predecessor parcel service. The driver and truck will travel back and forth between designated meeting points. European law restricts each driver to nine hours per day. Assuming an average travel speed of 100 kilometers per hour, the route is approximately 900 kilometers if the driver stays overnight at one meeting point. If two drivers are assigned to one truck, then the drive time of the truck can be doubled. Most routes are 450 kilometers each way, so the driver can go to the meeting point and return the same day. Most drivers prefer the 450 kilometer routes, so they can be home every night with their families. It also benefits Ford with fewer expenses, such as hotel rooms. The 450 kilometer routes are a win-win for all stakeholders.

6.3 Rebalancing Container Pool

Ford vehicle assembly and their suppliers are spread across Europe. The suppliers use a variety of durable containers, including FXC containers. Container movements to and from German component suppliers represent 25% of the total movements. Container movements to and from British and Spanish component suppliers represent 24% and 21% respectively. All other suppliers (using the FXC containers) located outside Germany, Belgium, Britain, and Spain represents 30% of the container movements. Vehicle production by the three assembly regions is as follows: Germany – 64%, Britain – 14%, and Spain – 22%. The six different models (Ka, Fiesta, Escort, Focus, Mondeo, and Transit) require a variety of components in a variety of packaging. As described in Chapter 2, the ratio of FXC per vehicle varies per vehicle line. The assembly plants demanded container movements based on the containers per model that they manufacture. Container movement based on assembly plant usage is as follows: German – 68%, British – 10%, and Spanish – 21%. The container pool requires FXC containers to be shipped from region to region. The only region to be nearly balanced is the Spanish region where the Spanish component suppliers require 553,414 FXC containers per year while the Valencia, Spain assembly plant requires 574,285 FXC containers per year. The German suppliers require 674,971 FXC containers while the three German assembly plants require 1,838,305 FXC containers; therefore the German Empty Pallet Compounds, located within the three German assembly plants, have an excess of 1,163,334 empty containers that are shipped to component suppliers in non-German regions. The British suppliers require 658,343 FXC containers while the British assembly plants require only 282,064 FXC containers; therefore the British assembly plants cannot support the British component suppliers' requirements. The shortfall or imbalance of –376,279 results in the non-British Empty Pallet Compounds to ship 376,279 containers to Britain. The closest non-British Empty Pallet Compound to Britain is Genk, Belgium, which is part of the German assembly region. The Genk, Belgium plant is also the least expensive transportation route from the continent plants to Britain. This transportation route from Genk to the British suppliers is further complicated due to the high production and container variance at Genk.

Table 6.3.A

Container Movements June 2000 through May 2001

	ASSEMBLY PLANTS					
Suppliers	GERMAN	BRITISH	SPANISH	Subtotals	Inbound %	Imbalance
German	518,430	54,825	101,716	674,971	25%	1,163,334
British	447,343	110,157	100,843	658,343	24%	-376,279
Spanish	299,836	46,262	207,316	553,414	21%	20,871
Other	572,696	70,820	164,410	807,926	30%	-807,926
Subtotals	1,838,305	282,064	574,285	2,694,654		
	68%	10%	21%			

The container imbalance requires attention to assure the component suppliers are properly supplied from the Empty Pallet Compounds. The region to region shipping not only requires more transportation resources (drives, trailers, diesel/gasoline) for the extra kilometers, but the region to region shipping requires more containers for the enlarged container pool to cover the extra shipping days during transportation. Chapter 7 investigates further the financial impact due to the imbalance and container pool requirements.

6.4 Pan-Brand Strategy across Ford, Jaguar, Land Rover, and Volvo

Seven assembly plants and approximately two hundred and seventy component suppliers utilize the Ford FXC pool. The assembly plants are located in four countries: United Kingdom, Belgium, Germany, and Spain, while the component suppliers are located in the fourteen countries: United Kingdom, Belgium, Germany, Spain, Czech Republic, France, Hungary, Italy, Netherlands, Poland, Portugal, Slovakia, Sweden, and Switzerland. The many countries stretch the FXC pool large distances, which result in lengthy transit times. The FXC pool is constrained by the existing locations of both the assembly plants and component suppliers. Most often component suppliers are located near the assembly plants. If the total overall cost to manufacture and ship the components from a far distance is the best option, then the components will travel the distance. During the twelve months from June 2000 through May 2001, the Ford division experienced an average transit time for inbound FXC container from component supplier to assembly plant of 3.28 days.

Container pooling of empties allows for containers to be routed from the best or closest locations. Inbound transit times are constrained by existing contracts, which are usually the best overall cost option. Outbound containers from the Empty Pallet Compound to component suppliers are nearly unconstrained. For example Czech component suppliers ship to Dagenham, England; Genk, Belgium; Cologne, Germany; Saarlouis, Germany; Southampton, England; and Valencia, Spain. Most of the FXC shipped back to the Czech Republic are sourced from Saarlouis and Genk; thus minimizing the return empty container routes. The Ford division experienced an average outbound transit time of 2.47 days for the twelve months from June 2000 through May 2001. As per Chapter 7, the optimal outbound transit for empty FXC would be 2.00 days.

The larger number of users within the fewest countries will allow for better utilization of the container pool. In Europe, both Ford and General Motors share some durable containers. The FXC is not utilized by General Motors, but is utilized by Jaguar and Land Rover. Volvo plans to incorporate the FXC containers into their supply chain soon. Ford Motor Company owns the Ford, Jaguar, Land Rover, and Volvo vehicle lines, which gives Ford Motor Company a strategic advantage for container pooling among vehicle lines. Within the auto industry, many component suppliers manufacture components for a variety of automotive manufacturers. Some of the European component suppliers manufacture for two or more vehicles within Ford Motor Company. The increased number of vehicle plants and component suppliers would require a larger pool of FXC containers. A shared pool would be less than the sum of individual pools. From mathematics and supply chain logistics, centralized or shared warehouses would require smaller safety stocks to compensate for the variances. In the Base Stock method used in this thesis, safety stock was $z * \sigma * \sqrt{(r + L)}$. Assuming z_i, σ_i, r_i, and L_i are the same for two different container pools that are independent and identically distributed (i =1 and 2), the shared pool will have a standard deviation σ_B, which would be equal to $\sigma * \sqrt{2}$.

$$\sigma = \sigma_1 = \sigma_2$$

$$\sigma_B = \sqrt{((\sigma_1)^2 + (\sigma_2)^2)}$$

$$\sigma_B = \sigma * \sqrt{2}$$

For individual safety stocks, the safety stock of pool 1 equals the safety stock of pool 2, $SS_i = SS_1 = SS_2$; hence the safety stock for both container pools is $2 * SSi = (SS_1 + SS_2)$. For a shared safety stock, the safety stock would require only $(\sqrt{2})/2$ or 71% of the sum of the two individual container pools $(0.707 * 2 * SS_i)$.

The Ford pool, independent of the other three Ford Motor Company brands, had an optimal average outbound transit time of 2.00 days, which equates to a cycle stock of 24,789 containers. Currently, Jaguar utilizes the FXC container with one vehicle line and intends to use the FXC container on two additional vehicle lines in the next two years. If Jaguar operates their container pool independent of other divisions (Ford, Land Rover, Volvo cars), the estimated outbound transit time is 5.6 days, which equates to an empty container outbound inventory of 3,197 containers. Land Rover is currently using the FXC container on one vehicle line. Land Rover intends to incorporate the FXC container into more vehicle lines, but no firm plans are in place. The Land Rover outbound transit time for their independent pool is 5.1 days, which equates to an empty container outbound inventory of 2,608 containers. The three independent pools would have a total cycle stock of 30,594 containers. When Ford Motor Company shares their FXC container resources among the three vehicle lines of Ford, Jaguar, and Land Rover, the empty container outbound inventory would be approximately 26,635 containers. The delta of 3,959 containers would equate to an annual savings of €158,360 ($140,940) in container leasing costs. In addition, transportation savings resulting from the shortened empty container return routes would be substantial. Safety stocks are a function of the vehicle production variance. Production data could not be obtained for Jaguar and Land Rover; therefore the safety stock savings could not be calculated.

Chapter 7: Simulation and Modeling

Chapter 7 simulates and models the Ford Motor Company European operations for the FXC container pool using supply chain principles as discussed in Chapter 6. In addition, Chapter 7 will utilize the logistics model and optimize with respect to expendable containers, durable containers, cycle stock, safety stocks, freight costs, shipping leadtimes, and container rebalancing issues. The optimization software, from *Frontline Systems* of Las Vegas, Nevada, is the "Large-Scale LP Solver Engine V4.0" and "Premium Solver Platform V4.0", which optimizes to find the best-case solution with respect to the operations parameters. The internship objectives included quantification of the existing processes, wastes, and inefficiencies and the determination of a Best-In-Class, robust service. Costs are based on the student's investigation of the Ford system. Daily vehicle production and daily container movements were based on a twelve-month sample from June 2000 through May 2001.

7.1 Logistics Overview

The FXC container pool is represented in a logistics model utilizing supply chain principles, primarily the Base Stock Model. Further supply chain information can be found within Section 6.1 Supply Chain Model. The FXC inventory consists of four components: inbound inventory, outbound inventory, safety stock, and container WIP inventory at the component suppliers and Ford assembly plants locations. Inbound inventory is constrained by the existing component suppliers and assembly plant locations. The eight days worth of container WIP inventory is from the predetermined five "free" days at the component suppliers and the three days at the assembly plants. Since inbound and WIP inventory are considered contractual constraints, only outbound inventory (empty container) was varied in the logistics model to determine optimal cost. Outbound container inventory is dependent on the outbound transportation, which can be one of a variety of methods: Pooling (consolidated freight), One-For-One Milk Runs, Pony Express, and others. For the logistics model optimization, the consolidated freight method was used for outbound transportation. The smallest safety stock method, Regional Safety Stock, is utilized in the optimization model.

Pool size and expendable risks are inversely related. The greater the number of FXC containers the lower the risk of expendable containers. Each extra container in the pool safety stock results in an annual cost of €64.08 ($57.03). Currently, the FXC process experiences 11.7 annual turns. Or in other words, a container travels through the process an average of 31.2 calendar days. Each occasion when a FXC container is unavailable results in incremental cost of €45.18 ($40.12). The probability of coverage (container available) from the safety stock is normally distributed. Table 7.1.A reiterates Section 6.1.2.2 Safety Stock by Region and 6.1.2.3 Safety Stock Rightsizing. Regional safety stock equates to 1,170 containers when z = 1. Table 7.1.A assumes 2,694,654 annual container movements. Further information is located in Section 2.7 Cost of Failures.

Table 7.1.A

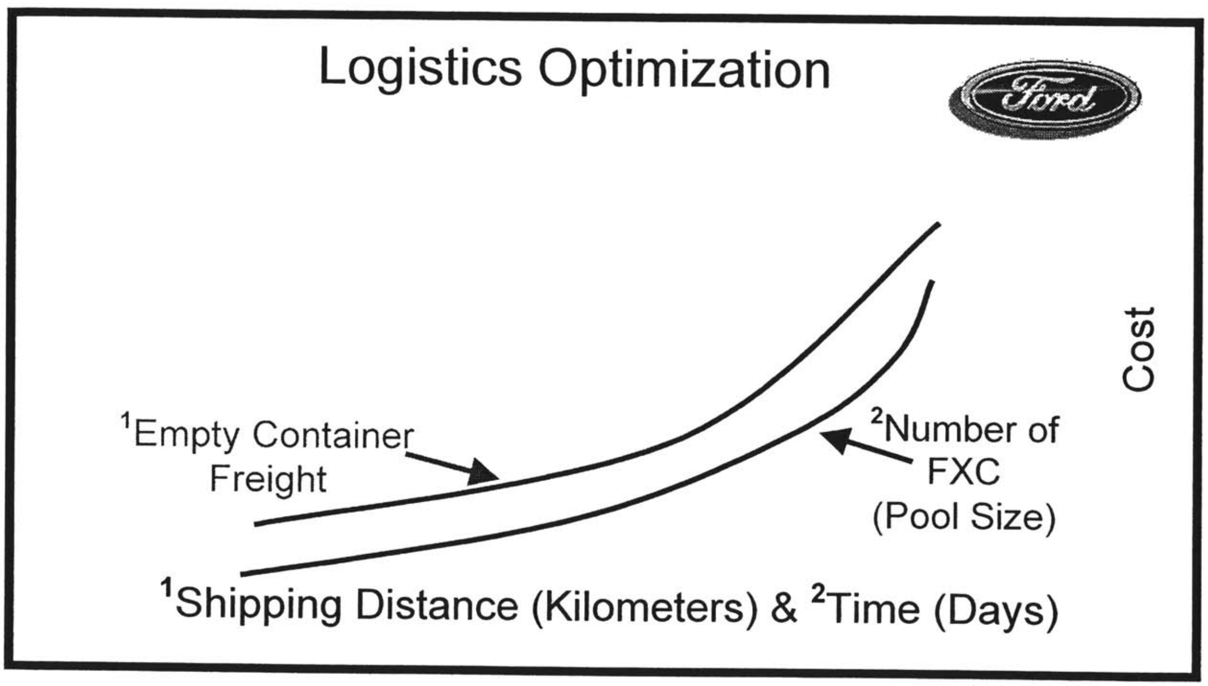
z	Probability of Coverage	Probability of Failure	Regional Safety Stock	Annual Occurences of Stock-out (Failure)
1	84.13447%	15.86553%	1,170	427,521
2	97.72499%	2.27501%	2,340	61,304
3	99.86500%	0.13500%	3,510	3,638
4	99.99683%	0.00317%	4,680	85

The length of time containers are in transit both inbound and outbound will affect the pool size and the risk of container shortages leading to the use of expendable containers. Inbound transportation times are constrained, while the outbound transportation times are flexible. Within the FXC process, the outbound transportation is also known as empty container freight. As shipping routes are chosen for best cost, the routes, which have decoupled shipping distances in kilometers and shipping time in days, will affect the container pool size and the expendable risk.

Diagrams 7.1.A, 7.1.B, and 7.1.C illustrate the logistics model optimization. The optimization software will minimize the sum of the three elements: empty container freight (outbound freight), FXC container pool cost, and expendable cost.

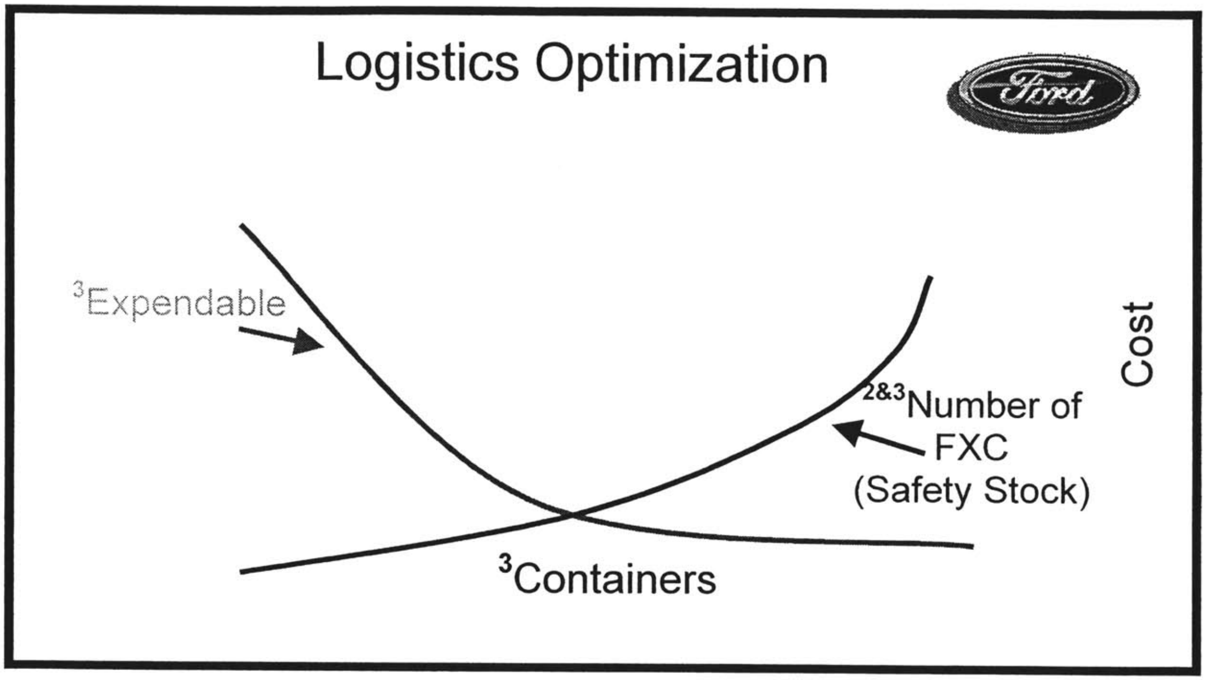
Empty container freight is the transportation costs for empty FXC containers shipped from the assembly plants to the component suppliers. As the empty container shipping (outbound) distance increases, the time on the trailers (L) will also increase; in addition, the empty container freight cost will increase. The container pool size is a function of the empty container transit time (L) and each additional container to the safety stock. As the empty container transit time increases, the container pool size will also increase due to the need for additional containers for the outbound transit. Additional FXC containers will result in higher costs. (See Diagram 7.1.A)

Diagram 7.1.A



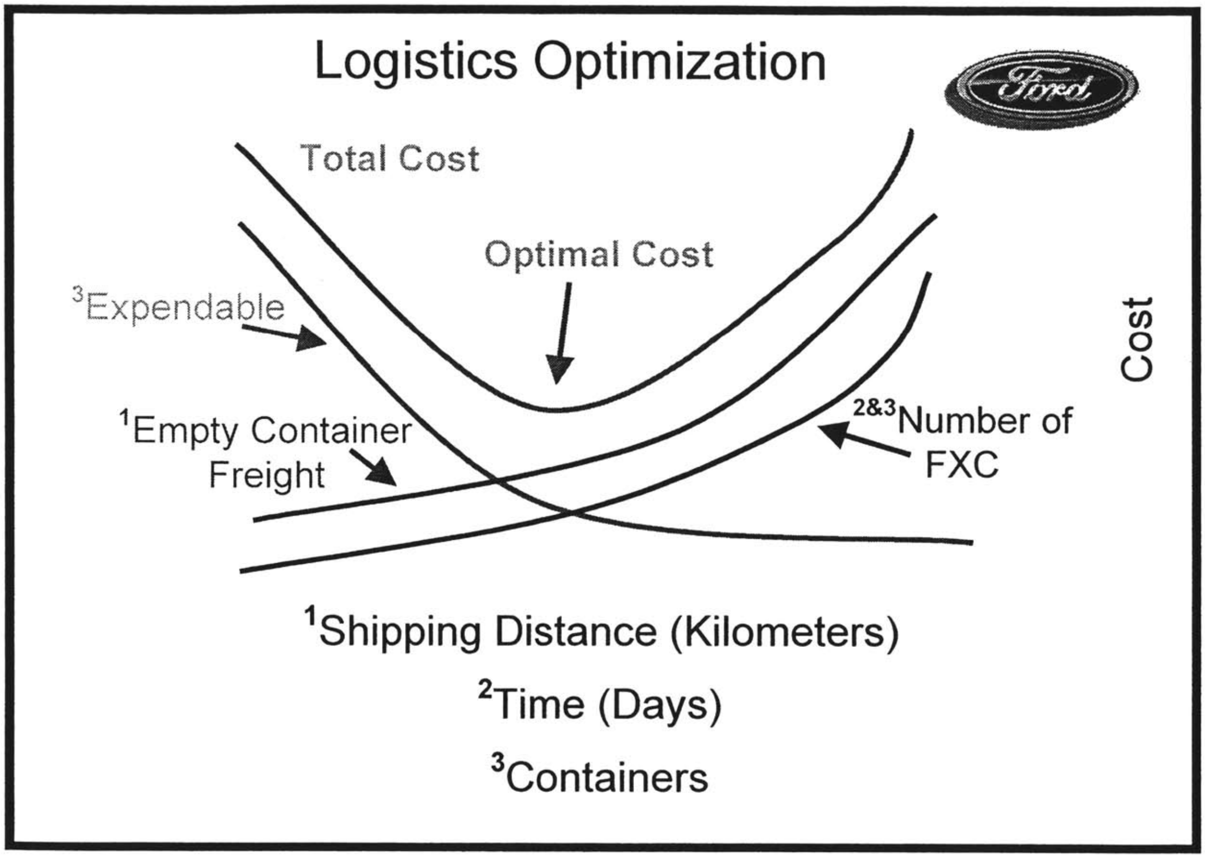
As the number of containers change, the FXC safety stock and the expendable (cardboard) occurrences will also change. As previously mentioned, the expendable cost is a function of risk and failure cost associated with the size of the safety stock. As the safety stock size increases, the expendable cost will decrease. (See Diagram 7.1.B)

Diagram 7.1.B



Therefore, the optimization is a non-linear iterative process that determines the optimal total cost as a function of the three elements: empty container freight, FXC container pool cost, and expendable cost. Diagram 7.1.C demonstrates the optimization in a high level format.

Diagram 7.1.C



7.2 Logistics Optimization

Within this section, Appendix G: Logistics Optimization for Ford Pan-European FLC/FSC is explained. Due to the confidential nature of supplier / Ford relationships, the prices used within the logistics model are not the Ford Motor Company prices. Instead, competitive market prices were used for the logistics model and sequential optimization.

7.2.1 Shipping

The empty container freight per container from Ford assembly plants to the approximate geographical center of each country is found in Appendix G, lines 4 through 20, shipping section. Further shipping data and costs are located in Appendix H: Shipping Data.

7.2.2 Component Supplier Demand

On line 26 and 27 of Appendix G, the annual demand of FXC containers from component suppliers to assembly plants is 2,694,654. Each component supplier must source empty FXC from these assembly plants to complete the supply chain. As demonstrated in Section 6.3, German and Belgium component suppliers source 25% and the Spanish component suppliers source 21% of the total 2.7 million empty FXCs from the assembly plants. In Appendix G, the component suppliers are grouped together by country except the Belgium, German, and Spanish component suppliers were modeled individually by Ford supplier code. Appendix K contains the Belgium and German component suppliers' FXC demand along with the component suppliers' distance in kilometers from the three German assembly plants: Genk, Belgium; Cologne, Germany, Saarlouis, Germany. Appendix J contains the Spanish component suppliers' FXC demand along with the component suppliers' distance in kilometers from the three German and one Spanish assembly plants: Genk, Belgium; Cologne, Germany; Saarlouis, Germany; Valencia, Spain. A few Belgium, German, and Spanish component suppliers' location information was insufficient; however, theses suppliers' demand was included in Appendix G, lines 188 through 191, using generic shipping costs based on each supplier's country average. Insufficient supplier location information for suppliers in Belgium, Germany, and Spain accounted for 191,225 containers movements for the June '00 – May '01 period (Belgium – 744, Germany – 180,664, Spain – 9,817). 38% of the total 2,694,654 container movements were modeled with actual distances from assembly plants to component suppliers.

7.2.3 Supply Decision Variables

Frontline Systems "Large-Scale LP Solver Engine V4.0" optimization software requires decision variables and constraints to operate. In Appendix G, cells D178 through J319, "Solver" incrementally varies the decision variables to find the optimal solution. Cells C178 through C191 contain component suppliers grouped by country. The Belgium, German, and Spanish component suppliers with insufficient location information are located in these groupings. Cells C192 through C319 contain the Belgium, German, and Spanish suppliers by Ford supplier code. Each supplier country or supplier code requires empty containers to match the Ford assembly plant demand (inbound). More information pertaining to the Ford assembly plant demand data can be found in Appendix I: Background Data. The constraints cells, M178 through M319, contain the inbound demand for all Ford assembly plants from each supplier (country and Ford supplier code). In other words, the suppliers will need to fill these numbers of empty containers for all Ford assembly plants. For example, the Czech suppliers ship components to six of the seven assembly plants for a total of 165,685 annual containers. The optimization software will decide in cells D178 through J319 how the empty containers should be sourced from the seven available assembly plants to the component suppliers, so that the constraints (inbound demand) are fulfilled while finding the optimal cost. As in the Czech example, the optimal solution demonstrates that the Czech suppliers should source the 165,685 empty FXC from the Saarlouis Empty Pallet Compound, since it the closest and most cost effective.

7.2.4 Empty Container Freight

The logistics optimization determines empty container freight in Appendix G, lines 346 through 487. The component suppliers grouped by country, lines 346 through 359, use the generic freight rates per empty FLC from assembly plant to country multiplied by their number of containers movements. The Belgium, German, and Spanish component suppliers by their Ford supplier code, lines 360 through 487, use a combination of the generic rates and distance to the assembly plants multiplied by their number of container movements. The sourcing routes between the Belgium and German component suppliers and the German assembly plants (Genk, Cologne, and Saarlouis) determine freight as a function of distance. Also, the sourcing routes between the Spanish component suppliers and the German and Spanish assembly plants (Genk, Cologne, Saarlouis, and Valencia) determine freight as a function of distance. The sourcing routes between the Belgium and German component suppliers and non-German assembly plants use the generic empty container rates. Also, the sourcing routes between the Spanish component suppliers and non-German and non-Spanish assembly plants use the generic empty containers rates.

7.2.5 Optimal Shipping Template

The optimization software determines the best cost while determining the optimal empty container sourcing from assembly plants to component suppliers. The empty container shipping template, summarized in lines 497 through 517 of Appendix G, allows the Durable Container Provider and Lead Logistics Partner to source containers at the best cost function with respect to empty container freight, container pool size, and expendable risk. Further details of the sourcing routes can be found in the decision variables of cells D178 through J319. As explained in Section 6.3 Rebalancing Container Pool, the Spanish component suppliers do not source all their empty containers from the Valencia, Spain assembly plant. As per the optimization, the component suppliers in the Northwest corner of Spain will source containers from Saarlouis, Germany. The distance from the Spanish Northwest to Saarlouis is 1,253 kilometers while the distance from the Spanish Northwest to Valencia is 781 kilometers. Even though Valencia is closer to the Spanish Northwest, the optimization software determined that the global optimal occurs when the Spanish component suppliers in close proximity to Valencia are sourced from Valencia. Saarlouis will source the Spanish routes that have the smallest difference between the sourcing options; for example in the Spanish Northwest corner case, the Saarlouis – Spanish Northwest is 1,253 kilometers while the Valencia – Spanish Northwest is 781 kilometers for a delta of 472 kilometers. Saarlouis is approximately 1,500 kilometers from Valencia. Some component suppliers are only 10 kilometers from Valencia. It would not be economically feasible for Saarlouis to source these component suppliers that are only 10 kilometers from Valencia, since the delta would be 1,490 kilometers while there are other Spanish component suppliers that could be sourced for a delta of 472 kilometers.

7.2.6 Average Empty Container Shipping Times and Pool Size Impact

When containers move from assembly plant to component supplier, there will be an outbound container inventory impact. For more information about outbound empty container inventory, see Section 6.1.1 Cycle Stock. The empty container sourcing routes are independent of the freight costs; therefore the sourcing routes must be represented as a cost to the pool size. Lines 539 through 680 of Appendix G utilize the transit times of lines 523 through 536 and the sourcing routes (decision variables) of lines 178 through 319. As per cell D682, the average empty container transit time is 2.0038 days. This is represented in the Base Stock Model as L =

2.0038 days. As the optimization software varies the decision variables (sourcing routes), the number of containers on the outbound shipping route will vary and the cardboard risk for the inbound material will also vary. The average daily movements were 12,394 containers; therefore 24,835 containers (2.0038 * 12,394) are utilized on the outbound sourcing routes. With an annual cost of €40 per container, the pool size impact is €993,369 annually, which is a function of the total optimal cost of cell D494.

7.2.7 FLC Safety Stock

The regional safety stock was utilized within the optimization model of Appendix G in lines 692 through 791. For further information, see Section 6.1.2.2 Safety Stock by Region. With standardized variant (z) of 1, review period (r) of 5 days, and leadtime (L) of 2.0038 days, the regional safety stock is 1,170 containers. As the optimization software varies the decision variables of lines 178 through 319, the outbound leadtime (L) for empty FXCs will also vary. From Chapter 6 safety stock = $z * \sigma * \sqrt{(r + L)}$, hence the safety stock and expendable risk will also vary as the decision variables vary. The resulting optimization is non-linear.

7.2.8 Safety Stock Cost Impact

The annual cost for each container in the safety stock is €64.08 (€40 for leasing plus the real estate cost of €24.08). Lines 794 through 820 of Appendix G optimize to find the best number of containers for the safety stock as a function of safety stock container cost and expendable risk. See Section 6.1.2.3 Safety Stock Rightsizing for more information. The optimal annual safety stock cost is €289,236 located in cell E817.

7.2.9 Optimal Costs

As previously demonstrated, the optimal cost is a function of Empty Container Freight, Pool Size Impact, and Safety Stock. Lines 489 through 493 of Appendix G, list the three variables of Optimal Cost. The summation of Empty Container Freight, Pool Size Impact, and Safety Stock is located in cell D494, which the optimization software will minimize.

Chapter 8: Greening Strategy

Ford of Europe has introduced durable plastic containers to enhance their greening strategy, which sends less solid waste and cardboard to landfills. Since the launch of the FLC in 1995, many process changes have been implemented. Chapter 8 reviews the greening strategy from a high level aspect utilizing Activity Base Costing, ABC. Further information about ABC can be found in Section 4.2.

8.1 FLC or Cardboard

There are two suppliers for the high-density polyethylene FLC in Europe, Linpac of England and Arca of France. Each company has unique proprietary designs for these containers. Regardless of the company, the FLC is approximately 63 kilograms and the competitive purchase price for a new FLC is €200 ($178, €1 = $0.89). Occasionally containers incur damage from material handling; for example, a highlow (forklift) may damage the base or wall. Damaged containers are usually repaired, but some containers are scraped. These containers are not sent to landfills, but are instead recycled by shredding the unusable container into pellets and feeding the pellets back into an injection-molding machine for the production of a new FLC. The scrap value of a FLC is approximately €12. The delta price, difference between the purchase price and scrap value, for a FLC is €188, which equates to €2.98/kilogram.

The alternative to the FLC is a cardboard box and wooden pallet. A cardboard box, of equivalent size to the FLC, weighs 8 kilograms and costs €22.56. In addition, the weight of the wooden pallet is 8 kilograms. In most European countries, there are penalties for waste generation. For example, the average cost to dispose of a box this size is €2.08. Therefore, Ford of Europe's cost for cardboard is approximately €24.64 per container or €1.54 per kilogram [(22.56 + 2.08) / 16].

The FXCs are reused and must travel back to the component suppliers to complete the supply chain cycle. The FXCs are reused approximately twelve cycles per year and have life expectancies of ten years, which results in a life cycle of one hundred and twenty uses per container. Using the annual cost of capital of 10%, the annual amortization of 10%, and the delta cost of €188, the cost per use would be €3.13 [(€188 * 20%) / 12]. Assuming the manpower cost for the return cycle back to the component supplier is €0.37 per container, the usage cost per cycle is €3.50. The empty container freight cost from assembly plant to component supplier is €2.60 per container (€7,000,229 – optimal annual return freight / 2,694,654 annual containers movements). The Ford cost for each FLC use is approximately €6.10. Therefore, each use of a FLC results in an approximate cost savings of €18.54 (€24.64 – €6.10). This does not include the one-third freight savings on the inbound, since FLCs are stacked three high while cardboard is constrained to only two high.

8.2 Crude Oil - Fuel versus Plastic Container

A Megatrailer can transport 182 empty FLCs, which weigh 11,466 kilograms. The Megatrailer will average 3 kilometers/liter or 7.1 miles/US gallon. Assuming the diesel price of €1.0/liter, the Megatrailer operates at €0.33/kilometer [(€1.0/liter) / (3 kilometers/liter)]; hence, each FLC costs €0.00183/kilometer in diesel fuel alone. With each FLC weighing 63 kilograms, the cost in diesel fuel for each kilometer-kilogram of high-density polyethylene is €0.0000291/kilometer-kilogram [€0.00183/kilometer) / 63 kilograms]. The truck and trailer have additional costs like driver and maintenance (oil, tires, etc.) costs. A competitive freight rate for a Megatrailer in Northern Europe is €1.02/kilometer; therefore the overall total freight cost for an empty FLC is €0.00560/kilometer. The freight unit cost is €0.0000890/kilometer-kilogram. From Section 8.1, the delta price for each FLC is €188 or €2.98/kilogram and each FLC has an expected life cycle of 120 uses. Therefore, the cycle cost is €0.0249/kilogram (€2.98/120 uses). If an empty container travels a significant distance, eventually the cost of transportation will exceed the value of the container. The break over point is the critical distance of which empty container shipping routes should be objectively benchmarked against. If the empty container shipping route is less than the critical distance, the route is economically feasible. If the empty container shipping route is greater than the critical distance, the route is not economically feasible. The cycle cost divided by the freight unit cost yields the critical distance in kilometers [(€/kilogram) / (€/kilometer-kilogram)]. Using the cycle cost of €0.0249 and the freight unit cost of €0.0000890/kilometer-kilogram yields a critical distance of 280 kilometers. Using the diesel fuel cost per kilometer-kilogram of €0.0000291, the critical distance for the diesel fuel usage is 855 kilometers. Ford of Europe is currently transporting empty FLCs a distance of 1,500 kilometers within the one-for-one routes. See Section 6.2.2 One-For-One Milk Runs for further transportation and inventory benefits of this policy.

Chapter 9: Conclusions

The global optimization performed in Chapter 7 determined the best empty container sourcing from assembly plants to component suppliers as a function of freight, pool size, and expendable. The results of Appendix G are a template for which the Durable Container Provider and the Lead Logistics Partner should utilize to generate the best financial and operational decisions.

The optimization study determined that during the time period of June 2000 through May 2001, Ford transportation of the empty FLC/FSC was not efficient. Using the empty container sourcing decisions from the twelve-month period and comparing them against the optimal solution of Chapter 7, the optimization determined that the Ford FLC/FSC pool was €1.6 million ($1.4 million) inefficient.

Due to time constraints, only 38% of the total container movements were modeled with their actual distances from assembly plants to component suppliers. It is recommended that this thesis be further expanded so all empty component movements are modeled with actual distances. In addition, the freight cost model should reflect any water transportation. This thesis assumed that the FLC and FSC are substitutes for one and another, and this thesis modeled them as one container pool. A new expanded model should separate the FLC and FSC as individual container pools. An expanded model could be built in *Microsoft* "Visual Basic" and then linked to Ford's CMMS-3 system, the Durable Container Provider's database, and the Lead Logistics Partner's database, thus allowing active data to be constantly updated.

Vehicle production variance was the cornerstone of the safety stock modeling. As vehicle production varies so do the containers at the Empty Pallet Compounds within the assembly plants. The next level of modeling should evaluate the variability and market forces of the component suppliers' orders upon the Empty Pallet Compounds.

Ford of Europe currently performs one-for-one shipping of empty FLC and FSC for routes up to 1,500 kilometers between the assembly plant and component supplier. It is recommended that this issue be revisited using a holistic methodology of inbound freight, outbound freight, container pool impact, expendable risks, and greening strategy.

This thesis investigated the Ford FLC/FSC pool alone. Ford Motor Company has four divisions in Europe (Ford, Jaguar, Land Rover, and Volvo) each operating their own container pool independently. A shared container pool would mutually benefit all four divisions. It is recommended that the same supply chain logistic techniques that were used in this thesis be applied to the larger Ford Motor Company family of vehicles.

As of May 2003, the Ford KLT leasing contract will be renewed. Ford should model and benchmark their processes and strategies in the same fashion of the FLC/FSC benchmarking exercise. Ford Motor Company of Europe should evaluate the KLT process across the four divisions of assembly and powertrain operations and leverage the benefits of risk pooling and a shared safety stock.

After this in-depth analysis of the interests and behaviors of the four FLC/FSC stakeholders (Ford, component suppliers, Durable Container Provider, and Lead Logistics Partner), the thesis author believes the current FLC/FSC process has sufficient rewards for all stakeholders that Ford Motor Company should continue to enhance the process. As mentioned in this thesis, Ford's core competency is vehicle assembly and not container management. For any automotive company to stay competitive in this very challenging business, container management should be contracted to a third party supplier who owns and manages the containers for the other stakeholders.

This thesis allows Ford to quantify the FLC/FSC process and determine achievable metrics for all stakeholders. Most importantly, this thesis allows Ford to determine Best-In-Class in their endless journey of continuous improvement. The Best Never Rest!

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Appendix A: Inventory Basics[22]

Supply chains consist of material and information flows. One of the primary material flows is the movement of physical products between stages in the supply chain. This note discusses two simple inventory models that are the building blocks for more complicated models developed later in the course.

General Inventory Issues

Model assumptions

- Single item at a single stage in the supply chain
- Stationary demand process
- Reliable replenishment process

Policy questions

- When to replenish?
- How much to replenish?

Parameters

- Demand characterization
- Replenishment lead-time (how long does it take to get re-supplied?)
- Reorder interval (are orders placed at certain times?)
- Costs
    - Holding costs – costs associated with the holding of inventory. This includes capital, obsolescence, and handling costs.
    - Order costs – costs associated with placing orders
- Fill rate – the level of service provided to the customer. In this note, we use fill rates in lieu of penalty costs.

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[22] This note is developed from lecture notes of Stephen C. Graves.

Continuous Review versus Periodic Review Policies

This section provides an overview of the two models discussed in this note.

Continuous review

- The inventory position, equal to the on-hand and on-order inventory level, is continuously monitored. When the inventory position drops below R units (the reorder point), order Q units (order quantity).

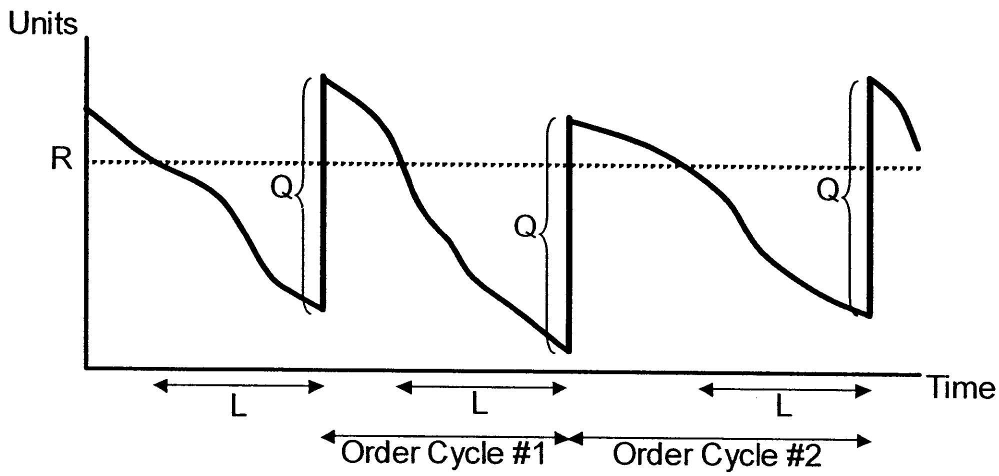


Figure 1: Continuous review policy (simulated values)

- In a continuous review system, the time between orders varies but the amount ordered is fixed.
    - We can see this point graphically in Figure 1: order cycles #1 and #2 are of different lengths but each order contains exactly Q units.
- The reorder point needs to be chosen so that sufficient inventory is available to cover the demand over the replenishment lead-time (L).
- This model is most appropriate for:
    - A items – high value items
    - fixed order sizes dictated by supplier (or manufacturing)

Periodic review

- The inventory position is monitored at periodic intervals of length r; orders are placed at fixed intervals of length r.
- Base stock policies are a special case of periodic review policies. In base stock policies, after an interval of length r has elapsed, the order quantity is set equal to the amount consumed during the interval.
    - In this note, we restrict ourselves to base stock policies.

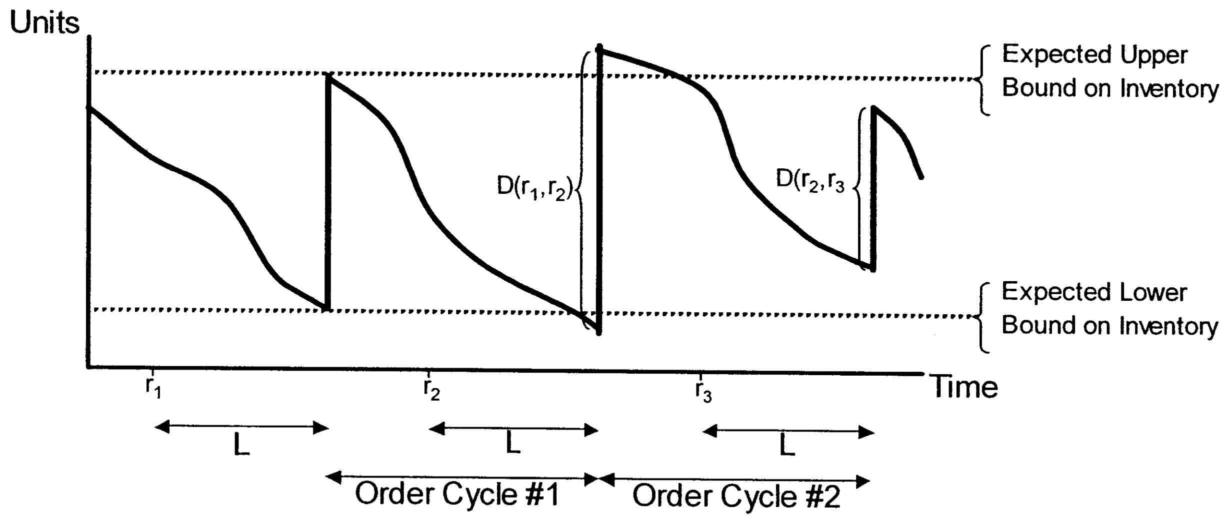


Figure 2: Periodic review policy (simulated values)

- In a periodic review system, the time between orders is fixed but the amount ordered varies.
    - We can see this graphically in Figure 2: order cycles #1 and #2 are the same length but the amount ordered in each interval is different.
- This model is most appropriate for:
    - fixed reorder intervals dictated by supplier (or by logistics department)
    - items that have a joint dependency. When two items have to be coordinated, then it may be beneficial to have them replenished at fixed times.
    - items with small order volume. In this case, it may be uneconomical to order the item in isolation.
    - low value items (C items). The low cost of these items may make the monitoring cost of a continuous system prohibitively expensive.

Mathematical Derivation of Expected Inventory Levels[23]

For each inventory policy, we characterize the expected on-hand inventory in an order cycle (defined as the time between two successive order arrivals). The expected inventory level will be a function of the policy's parameters and decision variable. We then characterize good choices for each policy's decision variable.

Continuous review

Assumptions

- We assume that demands in non-overlapping time intervals are independent. Let D(a, b) denote demand over the time interval from t = a to t = b; we assume that D(a, b) has expectation (b - a)μ, and variance (b - a)σ^2, where μ and σ^2 are the mean and variance of demand per unit time.
    - For example, these demand assumptions are consistent with a daily demand process that has a mean μ and variance σ^2. D(a, b) then characterizes the demand process over any interval of interest; say a few days, a week, a month or a year. This characterization is necessary since the order cycle is typically more than one day.
- We suppose that we continuously review the inventory; we reorder when the inventory *(on hand and on order)* reaches the order (or reorder) point R.
- When we reorder, we order an amount equal to the order quantity Q.
- The replenishment lead-time is a known constant L.

Inventory Dynamics

- Let I(t) denote the inventory at time t. At time of reorder (say time zero), the inventory position I(0) = R by definition of the policy
- At the time just prior to the replenishment, the on-hand inventory level $I(L)^-$ is

$$I(L)^- = R - D(0,L) \tag{1}$$

and the expectation of $I(L)^-$ is

[23] This analysis is approximate, where the key approximation is to treat backorders as negative inventory when determining the expected inventory level.

$$E[I(L)^{-}] = R - L\mu \quad (2)$$

- At the time just after the replenishment, the inventory level $I(L)^{+}$ is

$$I(L)^{+} = R - D(0,L) + Q \quad (3)$$

and the expectation of $I(L)^{+}$ is

$$E[I(L)^{+}] = R - L\mu + Q \quad (4)$$

- These inventory dynamics are illustrated graphically in the following figure

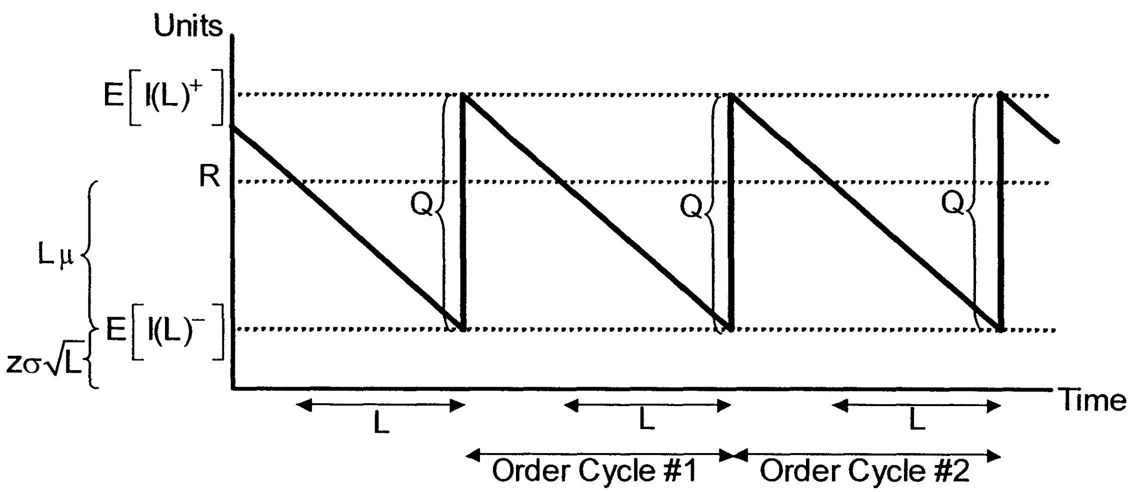


Figure 3: Expected behavior of continuous review system

- As this is true for every replenishment cycle, we can approximate the expected inventory level by the average of the expectations for the low and high points[24], given by (2) and (4):

$$\text{Expected inventory level} = R - L\mu + Q/2 \quad (5)$$

- We typically set R to cover the demand over the lead-time with high probability. The goal is to ensure that $I(L)^{-}$, from equation (1), is nonnegative with high probability. Assuming normally distributed demand, a common approach is to set R as

$$R = L\mu + z\sigma\sqrt{L} \quad (6)$$

[24] It may be helpful to look at Figure 3 and think back to high school geometry. A cycle's inventory area consists of a triangle sitting on top of a rectangle. The triangle's area is (½)(base) (height) with the height equal to $E[I(L)^{+}]$-[$I(L)^{-}$] and the base equal to the cycle length. The rectangle's area equals ($E[I(L)^{-}]$)(cycle length). Adding the two areas together yields (½)($E[I(L)^{+}]$ + $E[I(L)^{-}]$) (cycle length). The time horizon and stationarity assumption allow us to ignore cycle length.

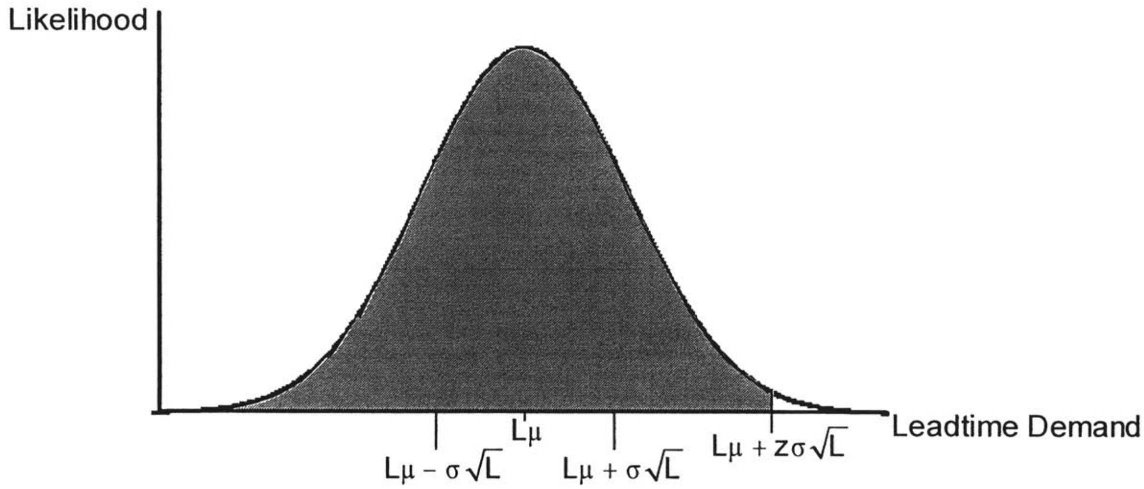
That is, we set R equal to the mean demand over the lead-time, plus some number (z = safety factor) of standard deviations of lead-time demand.

- Substituting (6) into (5) we have

$$\begin{aligned}\text{Expected inventory level} &= \frac{Q}{2} + z\sigma\sqrt{L} \\ &= \text{cycle stock} + \text{safety stock}\end{aligned} \tag{7}$$

<u>Digression: How to choose z?</u>

- The figure below represents the probability mass function of the random variable D(0,L), the demand over the leadtime.



As noted earlier, D(L) has a mean $L\mu$ and variance $L\sigma^2$.

- z corresponds to the number of standard deviations of protection the safety stock will cover.
    - If the realized demand over the lead-time is less than R, then a stock-out will not occur.
    - Typical choices for z:

z value	Prob. of no stock-out
1.645	0.95
2	0.98
3	0.999

Periodic Review

Assumptions

- We assume that demands in non-overlapping time intervals are independent. Let D(a, b) denote demand over the time interval from t = a to t = b; we assume that D(a, b) has expectation $(b - a)\mu$, and variance $(b - a)\sigma^2$, where μ and σ^2 are the mean and variance of demand per unit time.
    - For example, these demand assumptions are consistent with a daily demand process that has a mean μ and variance σ^2. D(a, b) then characterizes the demand process over any interval of interest; say a few days, a week, a month or a year. This characterization is necessary since the order interval is typically more than one day.
- We suppose that we place a replenishment order on a regular cycle, say at times t = r, 2r, 3r, ... where we call r the review period.
- The replenishment lead-time is a known constant L; thus we receive replenishments at times t = r+L, 2r+L, 3r+L, ...
- At each replenishment epoch, we order an amount equal to the demand since the last replenishment epoch. That is, at time t = r, we order D(0, r); at time t = 2r, we order D(r, 2r); at time t = 3r, we order D(2r, 3r), etc. These orders are received into inventory at times t = r+L, 2r+L, 3r+L, ...
- In effect, this is just how a "pull" system operates in discrete time.

Inventory Dynamics

- Define I(t) to be on-hand inventory at time t; I(t) equals some starting inventory, call it B = I(0), minus demand from time 0 to t, plus order replenishments received up to time t:

$$I(t) = B - D(0, t) + \text{order replenishments} \qquad (8)$$

- Consider t = kr + L for some integer k; then the inventory at time t = kr + L, just before receipt of the order is denoted $I(kr+L)^-$ and given by:

$$\begin{aligned} I(kr+L)^- &= B - D(0, kr+L) + D(0, r) + \dots + D((k-2)r, (k-1)r) \\ &= B - D((k-1)r, kr+L) \end{aligned} \qquad (9)$$

  and the expectation of $I(kr+L)^-$ is

$$E\left[I(kr+L)^-\right] = B - (r+L)\mu \qquad (10)$$

- By assumption, at time t = kr + L, we will receive the order placed at time t = kr for the amount D((k-1)r, kr), which raises the inventory to:

$$I(kr + L)^{+} = B - D(kr, kr + L) \tag{11}$$

and the expectation of $I(kr + L)^{+}$ is

$$E\left[I(kr + L)^{+}\right] = B - L\mu \tag{12}$$

- Equation (9) gives the "low" point for inventory in a replenishment cycle, while equation (11) gives the "high" point.
- These inventory dynamics are illustrated graphically in the following figure

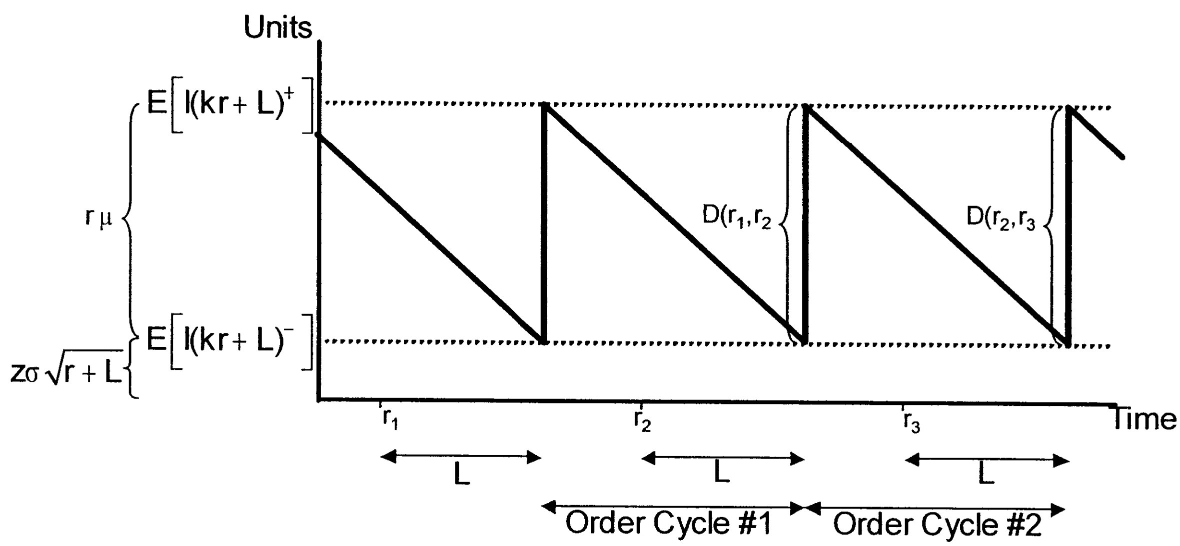


Figure 4: Expected behavior of periodic review system

- As this is true for every replenishment cycle, we can approximate the expected inventory level by the average of the expectations for the low and high points, given by (10) and (12):

$$\text{Expected inventory level} = B - L\mu - \frac{r\mu}{2} \tag{13}$$

- To determine how big B should be, we set B so that the probability of stock-out is small; that is, we want to have I(t) > 0 with high probability. We can assure this by assuring that it is true for the "low" inventory point given by (9). Thus, we need to set B so that with high probability

$$B > D((k-1)r, kr + L) \ .$$

The right hand side of the inequality is a random variable with mean (r +L)μ, and variance (r + L)σ^2; for normally distributed demand, we could then set

$$B = (r + L)\mu + z\sigma\sqrt{r + L} \quad (14)$$

where z is the safety factor, equal to the number of standard deviations of protection chosen. We term B to be the base stock.

- By substituting (14) into (13), we have that

$$\text{Expected inventory level} = (r + L)\mu + z\sigma\sqrt{r + L} - L\mu - \frac{r\mu}{2}$$

$$= \frac{r\mu}{2} + z\sigma\sqrt{r + L} \quad (15)$$

$$= \text{cycle stock} + \text{safety stock}$$

Conclusions

Summary of differentiating characteristics

Characteristic	Continuous Review	Periodic Review
Decision variable	Reorder point (R) Order quantity (Q)[25]	Reorder interval (r) Base stock (B)
Reorder interval	Variable	Fixed
Order quantity	Fixed	Variable
Expected inventory level	$\frac{Q}{2} + z\sigma\sqrt{L}$	$\frac{r\mu}{2} + z\sigma\sqrt{r + L}$
Candidate products	High value	Coordinated parts

Extensions

- The following issues will not be addressed today, they can be incorporated into these models:
  - Constraints on order sizes
  - Price discounts
  - Multiple sourcing options
  - Stochastic lead-times
  - Stochastic replenishment yields

[25] In this note, I do not address the optimal choice of Q. I have essentially assumed that it is either a fixed amount or determined using EOQ.

Stylized Example - Water bottle manufacturing

Problem Statement

- Consider a manufacturer of plastic water bottles. The sole raw material is plastic pellets. The firm's daily demand is normally distributed with a mean of 200 bottles/day and a variance of 120 bottles^2/day^2. The firm takes an inventory count and places orders on the first and third Monday of every month. The plastic supplier delivers an order within one week of receipt. The manufacturer is conservative when it comes to inventory (i.e., they hold a lot). Their justification is that the cost is minimal and it is unlikely to become obsolete since all they make are plastic bottles.
  a. What is the inventory policy?
  b. What are the parameters of interest?
  c. What is the expected inventory?

Solution

- Since orders are placed every two weeks, this is a periodic review model. Assuming 20 working days in a month, the reorder interval (r) is 10 days and the replenishment lead-time is 5 days. If the manufacturer chooses a fill rate of 98%, then z = 2. This results in the following inventory figures:

$$\text{Cycle stock} = \frac{r\mu}{2} = \frac{(10 \text{ days})(200 \text{ units/day})}{2} = 1000 \text{ units}$$

$$\text{Safety stock} = z\sigma\sqrt{r+L} = 2(10.95 \text{ units/day})\sqrt{10 \text{ days} + 5 \text{ days}} = 84.9 \text{ units}$$

Appendix B

Durable Container Provider Specification
Executive Summary

The attached specification is for a Durable Container Provider to coordinate overall movement of an estimated 230,000 FLC/FSC containers for the buyer, Ford Motor Company. The Durable Container Provider will be a partner in providing Best-In-Class functions with a world-class automotive manufacturer. The partnership is all-inclusive for all stakeholders within the Ford supply chain including the Ford component suppliers. It is essential that all stakeholders understand the underlying cost and process structures to achieve and sustain Best-In-Class. This specification is Ford's vision to encourage the right behaviour for all stakeholders to achieve and sustain Best-In-Class. Through continuous improvement and stakeholders' involvement, the process will continuously optimise to achieve the highest quality standards. Ford encourages others' foresight into our shared vision of a mutually beneficially process that provides a quality and robust service for all stakeholders.

The Durable Container Provider will fully disclose to Ford Motor Company all costs, rates and usages including those associated with the component suppliers. Full pricing and charging transparency is vital to Ford Motor Company for continuous improvement.

The Durable Container Provider will purchase the FLC containers and accept full responsibility of their property and container process. If, and when, overages occur from the durable container process, the Durable Container Provider will accept charges and accountability until sufficient documentation supports accountability onto other parties. The Durable Container Provider's accountability will include but not limited to charges for expendable containers, shipping including associated normal and premium shipping, repacking and rework costs.

The Durable Container Provider will supply and administrate a tracking system with 24/7 (24 hours/7 days a week) capability and visibility for all stakeholders. In addition, the tracking system will provide active locations of all 230,000 durable containers. All users of the system will have efficient access to quantities, shipments and hire charges, thus allowing active verification of all container movements, shipments and invoices.

Ford Motor Company will utilise the key cost drivers submitted in the Form of Quotation and determine if Ford personnel or the Durable Container Provider will operate the Empty Pallet Compound on a plant-by-plant base. Also, Ford Motor Company will utilise the repair processes and rates submitted by the Durable Container Provider in the Form of Quotation and determine which plants will allow repairs at the Ford assembly plants (EPCs) or at alternative locations external to the Ford Motor Company premises. Optimal safety stocks may be operated most efficiently from the EPCs. Again, Ford will utilise the costs on a plant-by-plant base. The rates will apply to any Ford assembly plant, unless the Durable Container Provider advises otherwise.

Ford Motor Company has established a Lead Logistics Provider (LLP) to coordinate material handling from suppliers to Ford assembly plants. The Durable Container Provider will fully cooperate and support the LLP in all Ford business activities, including but not limited to shipments from supplier to Ford locations, Ford locations to supplier, supplier to supplier and Ford locations to Ford locations.

Appendix B

When containers arrive at the Empty Pallet Compound, the containers will be taken off the plant's inventory and transferred to the Durable Container Provider account of safety stock. Furthermore whilst the containers are in transit from the EPC to the designated suppliers, there will be no daily hire for either the Ford assembly plants or component suppliers. The suppliers will receive no invoice unless the container remains as a part of the suppliers' WIP for more than the five free days. The supplier WIP is defined as the time the container arrives at the supplier until the container and the automotive components arrive at the supplier's shipping dock. The Durable Container Provider's tracking system will have the visibility to demonstrate clearly when containers are a part of the assemblers' WIP and suppliers' WIP. The Ford assembly plant WIP is defined as the time the container arrives at the supplier's shipping dock until the container arrives at the EPC.

The Lead Logistics Provider will have the flexibility to deliver containers before the suppliers' requested delivery date by up to two days in order to optimise freight costs. In this event, the Lead Logistics Provider will be responsible for paying hire charges for the days between actual delivery and the supplier specified order date. The Lead Logistics Provider will not be allowed to deliver containers late. If containers are not collected as per the Lead Logistics Provider pick up sheet and late delivery or non delivery of containers results in an expendable packaging claim by the supplier, then the Lead Logistics Provider will be responsible for paying the expendable packaging claim to the supplier. If the Lead Logistics Provider delivers a container sooner than the supplier's requested delivery date, the LLP will pay for the period between actual delivery date and the requested delivery date by the supplier.

It is vital that the total costs referenced in this pricing schedule are the same as the Key Cost Drivers tables. All assumptions made that are not stated in the specification should be clearly noted. When the Durable Container performs cost calculations, they will be expected to base their calculations on calendar year 2002 found within Attachment IV 2002 Projected Vehicle Production and Container Movements. The Durable Container Provider will provide all back up data for their calculations.

At the termination of the contract, Ford Motor Company or another Durable Container Provider will purchase the containers at the price equal to the un-amortized value. Section 4.0 Container Specification and 10.0 Liabilities and Amortization of this specification elaborate in more detail.

Appendix C: Durable Container Provider Presentation Format

Existing Capabilities and Company Culture

- Size, capability and experience of EU operation – supported by examples
- Company structure and ability to grow in Europe along with the method that would be used to achieve this
- Pan European experience with other automotive companies
- Pan European experience with non-automotive companies with similar durable container logistics
- Knowledge and understanding of Ford Motor Company's processes and initiatives (SMF / FPS / Q1 / ISO 9002 / Greening)
- Experience in managing a durable container service
- Experience in Empty Pallet Compound management
- Experience of developing processes in line with modern supply chain principles
- Experience of working within an Affordable Business Structure (Cost Targets) and modelling 'Total Cost'

Detailed Proposal Analysis

- Does the proposed strategy share Ford Motor Company's vision
- Is the strategy visible and efficient for all Stakeholders
- Cost estimation for management and overhead
- Cost estimation for container process and tracking system
- Cost estimation for Empty Pallet Compound
- Control and cost allocation for leakage (lost) containers
- Overall understanding of the functionally and financial requirements of the durable container process
- Establishing performance metrics, analysing associated data and driving through improvements to reduce 'Total Cost'
- Demonstrates a proactive approach to prevent process failures and unnecessary costs
- Tools used to monitor and improve quality of service
- Expertise in container pool forecasting, especially during model launches
- Ability to provide temporary durable containers compatible with FLC/FSC containers during high volume periods, especially during launches. Include cost structure.
- Established durable container tracking system in operation and fully functional
- Proposed safety stock locations are value added to the container process and the Ford supply chain
- Proposed cleaning process
- Accountability can be properly delegated onto the responsible Stakeholders
- Proposed repair process and are the potential candidate's suggestions obtainable
- Robust container acquisition and identification process
- Launch process and control mechanisms
- Launch time line
- Planned recruitment process
- Demonstrated a clear understanding of the Integration and Launch requirements

Appendix D: DCP Evaluation Form

DCP: ________________________ Evaluator: ________________________

A) Existing Capabilities and Company Culture

1) **Industry Knowledge and Commercial Capabilities in Europe**
The purpose of this selection element is to evaluate the extent of the potential candidate's experience and knowledge of European business practices and to assess their ability to expand in line with Ford Motor Company's Best-In-Class strategy throughout Europe.

Size, capability and experience of EU operation – supported by examples

Poor	Satisfactory	Good	Excellent
Comments			

Company structure and ability to grow in Europe along with the method that would be used to achieve this

Poor	Satisfactory	Good	Excellent
Comments			

Pan European experience with other automotive companies

Poor	Satisfactory	Good	Excellent
Comments			

Pan European experience with non-automotive companies with similar durable container logistics

Poor	Satisfactory	Good	Excellent
Comments			

Appendix D: DCP Evaluation Form

DCP: ______________________ **Evaluator:** ______________________

Knowledge and understanding of Ford Motor Company's processes and initiatives (SMF / FPS / Q1 / ISO 9002 / Greening)

Poor	Satisfactory	Good	Excellent
Comments			

2) Experience of a Durable Container Service

The purpose of this selection element is to evaluate the extent of the potential candidate's experience relative to the durable container service. Potential candidates should be prepared to comment on a range of current activities, their size and the roles and responsibilities within the operations.

Experience in managing a durable container service

Poor	Satisfactory	Good	Excellent
Comments			

Experience in Empty Pallet Compound management

Poor	Satisfactory	Good	Excellent
Comments			

Experience of developing processes in line with modern supply chain principles

Poor	Satisfactory	Good	Excellent
Comments			

Appendix D: DCP Evaluation Form

DCP: ______________________ **Evaluator:** ______________________

Experience of working within an Affordable Business Structure (Cost Targets) and modelling 'Total Cost'

Poor	Satisfactory	Good	Excellent
Comments			

B) Detailed Proposal Analysis

3) Commercial Issues
The purpose of this selection element is to evaluate the nature of the potential candidate's charging strategy to promote the proper behaviour of all Stakeholders to maximise the container pool and minimise total cost.

Does the proposed strategy share Ford Motor Company's vision

Poor	Satisfactory	Good	Excellent
Comments			

Is the strategy visible and efficient for all Stakeholders

Poor	Satisfactory	Good	Excellent
Comments			

Cost estimation for management and overhead

Poor	Satisfactory	Good	Excellent
Comments			

Appendix D: DCP Evaluation Form

DCP: ______________________ **Evaluator:** ______________________

Cost estimation for container process and tracking system

Poor	Satisfactory	Good	Excellent
Comments			

Cost estimation for Empty Pallet Compound

Poor	Satisfactory	Good	Excellent
Comments			

Control and cost allocation for leakage (lost) containers

Poor	Satisfactory	Good	Excellent
Comments			

Overall understanding of the functionally and financial requirements of the durable container process

Poor	Satisfactory	Good	Excellent
Comments			

4) **Approach to Continuous Improvement and Quality**
The purpose of this selection element is to evaluate the nature of the potential candidate's organizational culture and the initiatives undertaken with regard to continuous improvement. Utilising relevant examples, potential candidates should demonstrate an ability to identify and implement improvements in cost and quality.

Appendix D: DCP Evaluation Form

Ford

DCP: ____________________ **Evaluator:** ____________________

Establishing performance metrics, analysing associated data and driving through improvements to reduce 'Total Cost'

Poor	Satisfactory	Good	Excellent
Comments			

Demonstrates a proactive approach to prevent process failures and unnecessary costs

Poor	Satisfactory	Good	Excellent
Comments			

Tools used to monitor and improve quality of service

Poor	Satisfactory	Good	Excellent
Comments			

Expertise in container pool forecasting, especially during model launches

Poor	Satisfactory	Good	Excellent
Comments			

Ability to provide temporary durable containers compatible with FLC/FSC containers during high volume periods, especially during launches. Include cost structure.

Poor	Satisfactory	Good	Excellent
Comments			

Appendix D: DCP Evaluation Form

DCP: ______________________ **Evaluator:** ______________________

5) **Container Process and Delegating Proper Accountability**
The purpose of this selection element is to evaluate the nature of the potential candidate's abilities to effectively track and control the FLC/FSC container pool. In addition, the potential candidate will accept and champion accountability until sufficient documentation supports otherwise. It is in all Stakeholders' best interests, especially Ford Motor Company's best interest, that accountability is properly delegated to encourage the proper behaviour among all Stakeholders.

Established durable container tracking system in operation and fully functional

Poor	Satisfactory	Good	Excellent
Comments			

Proposed safety stock locations are value added to the container process and the Ford supply chain

Poor	Satisfactory	Good	Excellent
Comments			

Proposed cleaning process

Poor	Satisfactory	Good	Excellent
Comments			

Accountability can be properly delegated onto the responsible Stakeholders

Poor	Satisfactory	Good	Excellent
Comments			

Appendix D: DCP Evaluation Form

DCP: ______________________ **Evaluator:** ______________________

Proposed repair process and are the potential candidate's suggestions obtainable

Poor	Satisfactory	Good	Excellent
Comments			

6) Integration and Launch

The purpose of this selection element is to evaluate the nature of the potential candidate's abilities to ensure a comprehensive and timely integration and launch.

Robust container acquisition and identification process

Poor	Satisfactory	Good	Excellent
Comments			

Launch process and control mechanisms

Poor	Satisfactory	Good	Excellent
Comments			

Launch time line

Poor	Satisfactory	Good	Excellent
Comments			

Appendix D: DCP Evaluation Form

DCP: ______________________ **Evaluator:** ______________________

Planned recruitment process

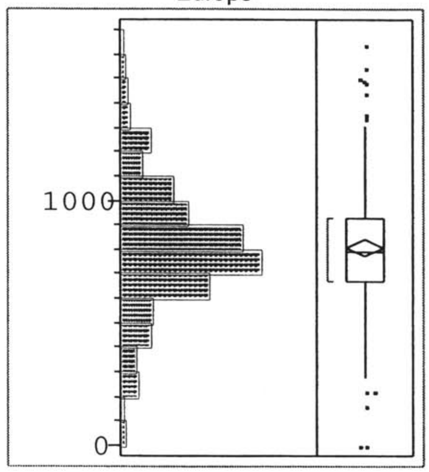
Poor	Satisfactory	Good	Excellent
Comments			

Demonstrated a clear understanding of the Integration and Launch requirements

Poor	Satisfactory	Good	Excellent
Comments			

Appendix E: Empty Pallet Compounds – Safety Stocks

Europe



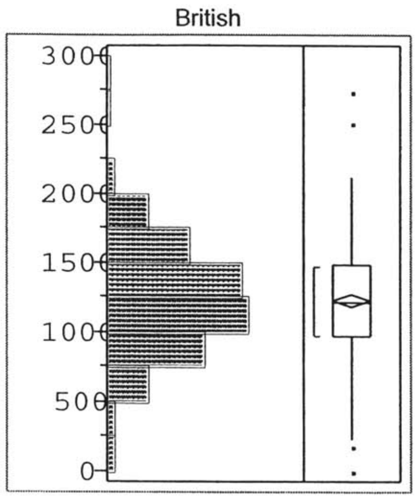
Quantiles

maximum	100.0%	16449
	99.5%	16168
	97.5%	14033
	90.0%	11864
quartile	75.0%	9297
median	50.0%	7976
quartile	25.0%	6701
	10.0%	4652
	2.5%	2863
	0.5%	0
minimum	0.0%	0

Moments

Mean	8109.346
Std Dev	2623.576
Std Error Mean	162.707
Upper 95% Mean	8429.748
Lower 95% Mean	7788.944
N	260.000
Sum Weights	260.000
Sum	2108430
Variance	6883150.5
Skewness	0.127
Kurtosis	0.948
CV	32.352

Appendix E: Empty Pallet Compounds – Safety Stocks



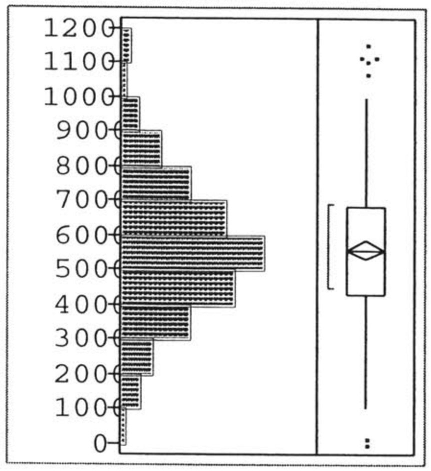
Quantiles

maximum	100.0%	2757.0
	99.5%	2711.8
	97.5%	1979.4
	90.0%	1732.3
quartile	75.0%	1488.8
median	50.0%	1220.0
quartile	25.0%	984.0
	10.0%	767.9
	2.5%	470.3
	0.5%	36.1
minimum	0.0%	0.0

Moments

Mean	1236.244
Std Dev	396.870
Std Error Mean	25.725
Upper 95% Mean	1286.924
Lower 95% Mean	1185.564
N	238.000
Sum Weights	238.000
Sum	294226
Variance	157506.14
Skewness	0.170
Kurtosis	0.908
CV	32.103

Appendix E: Empty Pallet Compounds – Safety Stocks



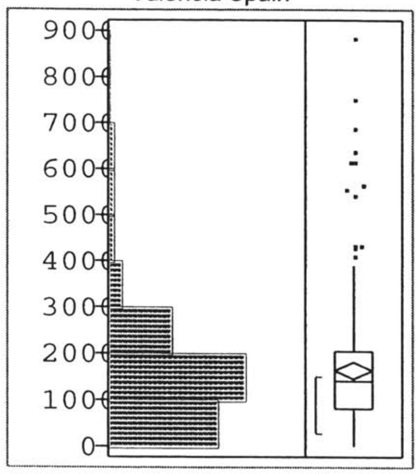
Quantiles

maximum	100.0%	11601
	99.5%	11507
	97.5%	9953
	90.0%	8348
quartile	75.0%	6864
median	50.0%	5583
quartile	25.0%	4353
	10.0%	3139
	2.5%	1629
	0.5%	58
minimum	0.0%	4

Moments

Mean	5627.567
Std Dev	2060.154
Std Error Mean	129.778
Upper 95% Mean	5883.162
Lower 95% Mean	5371.973
N	252.000
Sum Weights	252.000
Sum	1418147
Variance	4244234.9
Skewness	0.175
Kurtosis	0.302
CV	36.608

Appendix E: Empty Pallet Compounds – Safety Stocks



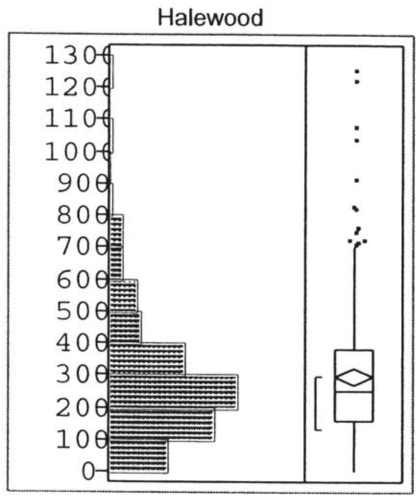
Quantiles

maximum	100.0%	8892.0
	99.5%	8632.3
	97.5%	6192.9
	90.0%	2894.4
quartile	75.0%	2088.0
median	50.0%	1422.0
quartile	25.0%	819.0
	10.0%	444.9
	2.5%	23.4
	0.5%	0.0
minimum	0.0%	0.0

Moments

Mean	1664.105
Std Dev	1334.338
Std Error Mean	86.492
Upper 95% Mean	1834.499
Lower 95% Mean	1493.711
N	238.000
Sum Weights	238.000
Sum	396057
Variance	1780456.7
Skewness	2.196
Kurtosis	6.895
CV	80.183

Appendix E: Empty Pallet Compounds – Safety Stocks



Quantiles

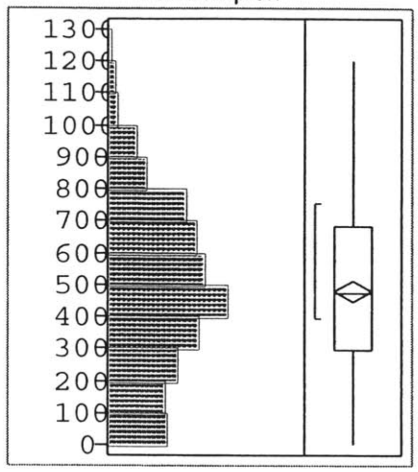
maximum	100.0%	1267.0
	99.5%	1260.6
	97.5%	837.2
	90.0%	564.7
quartile	75.0%	381.0
median	50.0%	252.0
quartile	25.0%	160.5
	10.0%	86.0
	2.5%	24.9
	0.5%	2.3
minimum	0.0%	0.0

Moments

Mean	296.8445
Std Dev	210.8439
Std Error Mean	13.6670
Upper 95% Mean	323.7692
Lower 95% Mean	269.9199
N	238.0000
Sum Weights	238.0000
Sum	70649
Variance	44455.17
Skewness	1.7050
Kurtosis	4.0815
CV	71.0284

Appendix E: Empty Pallet Compounds – Safety Stocks

Southampton



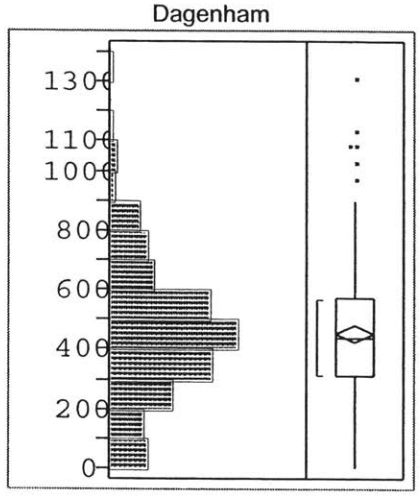
Quantiles

maximum	100.0%	1203.0
	99.5%	1196.0
	97.5%	1032.7
	90.0%	810.8
quartile	75.0%	686.0
median	50.0%	474.0
quartile	25.0%	299.5
	10.0%	128.4
	2.5%	17.8
	0.5%	0.0
minimum	0.0%	0.0

Moments

Mean	483.5063
Std Dev	260.0125
Std Error Mean	16.8896
Upper 95% Mean	516.7804
Lower 95% Mean	450.2322
N	237.0000
Sum Weights	237.0000
Sum	114591
Variance	67606.497
Skewness	0.1588
Kurtosis	-0.4183
CV	53.7764

Appendix E: Empty Pallet Compounds – Safety Stocks

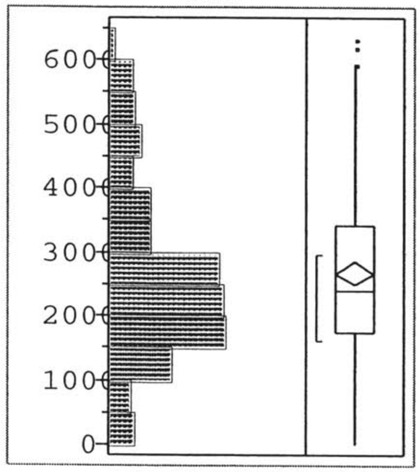


Quantiles		
maximum	100.0%	1320.0
	99.5%	1284.9
	97.5%	979.4
	90.0%	778.8
quartile	75.0%	575.8
median	50.0%	444.0
quartile	25.0%	317.3
	10.0%	164.0
	2.5%	28.0
	0.5%	0.0
minimum	0.0%	0.0

Moments	
Mean	457.9244
Std Dev	228.0045
Std Error Mean	14.7793
Upper 95% Mean	487.0404
Lower 95% Mean	428.8084
N	238.0000
Sum Weights	238.0000
Sum	108986
Variance	51986.062
Skewness	0.4712
Kurtosis	0.7396
CV	49.7909

Appendix E: Empty Pallet Compounds – Safety Stocks

Genk



Quantiles

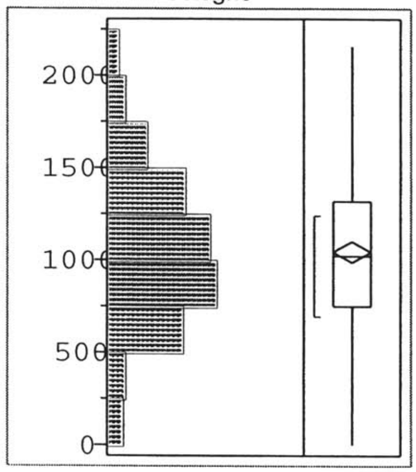
maximum	100.0%	6366.0
	99.5%	6333.5
	97.5%	5744.7
	90.0%	4889.9
quartile	75.0%	3437.3
median	50.0%	2419.5
quartile	25.0%	1761.3
	10.0%	1142.8
	2.5%	157.1
	0.5%	0.0
minimum	0.0%	0.0

Moments

Mean	2681.260
Std Dev	1388.829
Std Error Mean	89.277
Upper 95% Mean	2857.126
Lower 95% Mean	2505.395
N	242.000
Sum Weights	242.000
Sum	648865
Variance	1928846.2
Skewness	0.576
Kurtosis	-0.102
CV	51.798

Appendix E: Empty Pallet Compounds – Safety Stocks

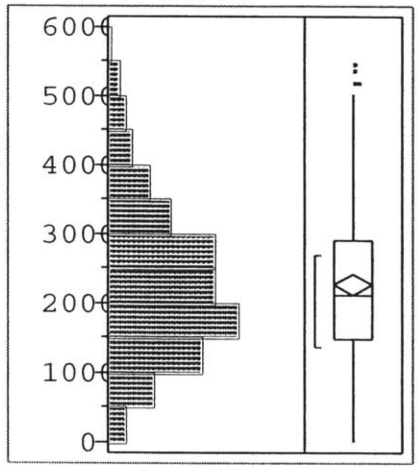
Cologne



Quantiles		
maximum	100.0%	2170.0
	99.5%	2168.5
	97.5%	2020.5
	90.0%	1625.8
quartile	75.0%	1325.0
median	50.0%	1028.0
quartile	25.0%	757.5
	10.0%	543.6
	2.5%	136.0
	0.5%	0.0
minimum	0.0%	0.0

Moments	
Mean	1056.100
Std Dev	427.587
Std Error Mean	28.763
Upper 95% Mean	1112.786
Lower 95% Mean	999.413
N	221.000
Sum Weights	221.000
Sum	233398
Variance	182830.64
Skewness	0.185
Kurtosis	0.097
CV	40.487

Appendix E: Empty Pallet Compounds – Safety Stocks



Quantiles

maximum	100.0%	5500.0
	99.5%	5484.5
	97.5%	4984.2
	90.0%	3888.8
quartile	75.0%	2925.0
median	50.0%	2150.0
quartile	25.0%	1512.0
	10.0%	1002.6
	2.5%	439.5
	0.5%	0.0
minimum	0.0%	0.0

Moments

Mean	2291.570
Std Dev	1116.315
Std Error Mean	73.608
Upper 95% Mean	2436.606
Lower 95% Mean	2146.533
N	230.000
Sum Weights	230.000
Sum	527061
Variance	1246158.5
Skewness	0.561
Kurtosis	0.140
CV	48.714

Appendix E: Daily Levels of FLC/FSC at Empty Pallet Compounds

Date	Cologne	Genk	Saarlouis	Valencia	Dagenham	Halewood	Southampton	TOTAL
6/1/2000	*	*	*	2569	384	423	348	**3724**
6/2/2000	*	*	*	1356	534	490	438	**2328**
6/5/2000	924	4824	5500	2136	330	365	866	**14945**
6/6/2000	504	4296	5232	2508	348	97	456	**13441**
6/7/2000	294	4562	4668	1896	564	212	271	**12467**
6/8/2000	532	4314	4944	1896	792	404	184	**13066**
6/9/2000	1092	3160	4536	2784	756	548	136	**12464**
6/12/2000	1092	3160	4536	3780	792	559	584	**14503**
6/13/2000	1722	2342	2300	3228	360	564	449	**10965**
6/14/2000	1274	2964	2544	3816	506	732	530	**12366**
6/15/2000	1673	3205	3076	3924	312	708	710	**13608**
6/16/2000	1064	2886	3720	3432	293	699	642	**12037**
6/19/2000	1337	2535	4056	2544	324	516	596	**11908**
6/20/2000	753	3604	4080	1944	257	448	438	**11524**
6/21/2000	1066	3826	3192	1450	360	380	451	**10725**
6/22/2000	*	3149	*	1104	624	310	178	**5365**
6/23/2000	*	208	*	1512	433	540	237	**5365**
6/26/2000	1752	871	3200	1166	473	728	596	**8786**
6/27/2000	966	1652	816	1140	396	692	461	**6123**
6/28/2000	1044	3304	0	1332	324	365	566	**6935**
6/29/2000	1089	4444	1152	1848	318	545	415	**9811**
6/30/2000	1452	5430	4356	2880	426	722	263	**9811**
7/3/2000	1397	5432	3920	2630	483	571	508	**14941**
7/4/2000	1412	5563	4176	2520	432	600	370	**15073**
7/5/2000	1686	5619	4296	2736	612	828	672	**16449**
7/6/2000	854	5692	1992	2544	362	732	351	**12527**
7/7/2000	520	5127	3192	1440	428	924	380	**11087**
7/10/2000	*	4930	*	1860	426	756	680	**8652**
7/11/2000	*	3871	*	1968	156	1267	357	**7619**
7/12/2000	*	2605	*	2112	570	1234	229	**6750**
7/13/2000	*	2929	*	0	854	1085	39	**4907**
7/14/2000	*	2103	*	0	1140	1049	336	**3579**
7/17/2000	*	2120	*	1296	1320	835	602	**6173**
7/18/2000	*	2857	*	1104	1092	229	554	**5836**

Appendix E: Daily Levels of FLC/FSC at Empty Pallet Compounds

Date	Cologne	Genk	Saarlouis	Valencia	Dagenham	Halewood	Southampton	TOTAL
7/19/2000	*	2898	*	1800	789	544	164	**6195**
7/20/2000	*	2168	*	3084	900	191	143	**6486**
7/21/2000	*	2168	*	4368	25	214	0	**6486**
7/24/2000	*	2088	*	5472	*	*	*	**7560**
7/25/2000	*	2133	*	6420	*	*	*	**8553**
7/26/2000	*	1750	*	6912	*	*	*	**8662**
7/27/2000	*	1300	*	7560	*	*	*	**8860**
7/28/2000	*	4	*	8892	*	*	*	**8860**
7/31/2000	0	0	3500	6229	0	0	0	**9729**
8/1/2000	*	*	3564	5714	*	*	*	**9278**
8/2/2000	*	*	4968	3263	*	*	*	**8231**
8/3/2000	*	*	5040	2681	*	*	*	**7721**
8/4/2000	*	*	5400	2451	*	*	*	**7851**
8/7/2000	273	*	3900	*	*	*	*	**4173**
8/8/2000	273	*	2916	*	*	*	*	**3189**
8/9/2000	749	*	3336	*	*	*	*	**4085**
8/10/2000	1028	*	3072	*	*	*	*	**4100**
8/11/2000	1489	*	1900	*	*	*	*	**3389**
8/14/2000	1820	*	2016	*	214	86	398	**4534**
8/15/2000	1400	*	2016	*	214	86	246	**3962**
8/16/2000	1225	154	2592	*	280	86	106	**4443**
8/17/2000	924	1797	2304	*	752	12	22	**5811**
8/18/2000	589	3378	2136	*	1034	22	64	**7201**
8/21/2000	2059	2927	2400	*	809	134	96	**8425**
8/22/2000	2170	2268	4272	*	36	147	2	**8895**
8/23/2000	1938	1457	3744	*	140	117	2	**7398**
8/24/2000	1285	1360	3168	*	262	109	34	**6218**
8/25/2000	1305	1528	2712	*	509	34	71	**6218**
8/28/2000	1989	1320	1840	192	*	*	*	**5341**
8/29/2000	1899	1642	1632	595	828	31	70	**7314**
8/30/2000	1640	1635	3168	1863	840	19	72	**9522**
8/31/2000	1264	2405	3072	1368	608	28	220	**10753**
9/1/2000	1117	2457	1584	2568	276	49	181	**8183**
9/4/2000	1195	3108	2616	2820	383	42	132	**10296**

Appendix E: Daily Levels of FLC/FSC at Empty Pallet Compounds

Date	Cologne	Genk	Saarlouis	Valencia	Dagenham	Halewood	Southampton	TOTAL
9/5/2000	1134	2641	3072	516	600	36	212	**8211**
9/6/2000	770	2520	1822	612	852	30	294	**6900**
9/7/2000	673	2161	1944	516	978	54	288	**6614**
9/8/2000	785	1245	2880	1512	865	81	106	**7393**
9/11/2000	1223	912	2256	3072	778	96	237	**8574**
9/12/2000	1209	1571	2388	2556	694	52	210	**8680**
9/13/2000	1281	1736	3528	2316	558	77	701	**10197**
9/14/2000	935	1990	2016	2376	652	97	561	**8627**
9/15/2000	892	0	170	1308	743	144	720	**3833**
9/18/2000	1593	1079	1600	924	588	175	800	**6759**
9/19/2000	1480	1283	3432	432	318	216	602	**7763**
9/20/2000	1515	1441	4956	828	262	135	352	**9489**
9/21/2000	1909	0	5232	1512	582	83	312	**9630**
9/22/2000	1515	2009	3912	2364	532	39	401	**9630**
9/25/2000	2096	1906	1368	2052	468	80	852	**8822**
9/26/2000	1526	2211	2424	2196	474	12	505	**9348**
9/27/2000	1070	2257	2652	1080	403	30	404	**7896**
9/28/2000	404	2111	2640	1740	264	25	420	**7604**
9/29/2000	627	2392	2652	2100	438	89	500	**7604**
10/2/2000	1743	1296	*	914	322	132	202	**4609**
10/3/2000	*	1475	*	3116	396	186	456	**7372**
10/4/2000	480	864	300	6192	620	230	500	**9186**
10/5/2000	826	1096	1512	5596	884	144	580	**10638**
10/6/2000	749	1594	792	4408	824	182	672	**9039**
10/9/2000	693	1814	720	*	560	300	479	**8974**
10/10/2000	1372	2426	1152	1740	636	154	371	**7851**
10/11/2000	1305	2538	1752	445	816	230	300	**7386**
10/12/2000	1064	2100	1512	*	786	150	516	**6128**
10/13/2000	149	2068	1008	445	396	159	333	**4399**
10/16/2000	665	1402	750	936	492	146	299	**4690**
10/17/2000	899	2458	956	1020	210	132	456	**6131**
10/18/2000	809	3129	624	1152	530	192	776	**7212**
10/19/2000	707	3533	1632	660	672	170	408	**7782**
10/20/2000	753	2951	2784	360	616	130	294	**7758**

Appendix E: Daily Levels of FLC/FSC at Empty Pallet Compounds

Date	Cologne	Genk	Saarlouis	Valencia	Dagenham	Halewood	Southampton	TOTAL
10/23/2000	962	1632	3024	2556	1094	175	444	**9887**
10/24/2000	1071	1092	2784	2076	288	204	562	**8077**
10/25/2000	965	1161	2928	1440	307	244	905	**7950**
10/26/2000	939	2442	1320	1188	318	161	688	**7056**
10/27/2000	834	2932	192	1824	468	134	721	**7056**
10/30/2000	1323	2859	900	2688	430	142	524	**8866**
10/31/2000	1042	1771	1056	1524	511	137	278	**6319**
11/1/2000	1042	1771	1056	1524	373	230	450	**6446**
11/2/2000	994	1634	1950	1620	559	324	700	**7781**
11/3/2000	504	2442	1632	432	348	348	971	**6329**
11/6/2000	875	2796	865	1848	425	288	896	**7993**
11/7/2000	752	3303	1152	2028	554	165	1054	**9008**
11/8/2000	539	2981	2160	1476	634	180	1100	**9070**
11/9/2000	360	2629	2016	1068	3	253	1047	**7376**
11/10/2000	691	1953	1728	480	460	231	1203	**6515**
11/13/2000	882	1080	750	1656	394	140	694	**5596**
11/14/2000	770	372	480	1692	398	264	672	**4648**
11/15/2000	1462	432	1584	1896	424	288	516	**6602**
11/16/2000	1261	889	2592	2472	554	186	400	**8354**
11/17/2000	704	2943	2712	2496	660	264	635	**10150**
11/20/2000	987	4653	2300	2340	818	150	741	**11989**
11/21/2000	1218	3840	3216	840	538	190	808	**10650**
11/22/2000	967	3453	2328	720	602	240	786	**9096**
11/23/2000	1028	2880	2352	2088	379	192	490	**9409**
11/24/2000	822	3866	552	2484	387	168	529	**8640**
11/27/2000	1075	3885	560	2304	440	252	520	**9036**
11/28/2000	1030	3676	1056	1788	581	300	566	**8997**
11/29/2000	834	2926	1728	1344	723	200	684	**8439**
11/30/2000	800	2768	2592	600	809	288	523	**8380**
12/1/2000	704	2775	2592	612	456	174	588	**7727**
12/4/2000	1089	2142	720	756	159	276	206	**5348**
12/5/2000	1043	2347	1152	588	173	324	456	**6083**
12/6/2000	825	3343	2760	588	195	175	344	**8230**
12/7/2000	683	4246	2808	475	204	252	137	**8805**

Appendix E: Daily Levels of FLC/FSC at Empty Pallet Compounds

Date	Cologne	Genk	Saarlouis	Valencia	Dagenham	Halewood	Southampton	TOTAL
12/8/2000	758	4806	2688	475	283	222	332	**9342**
12/11/2000	1004	4477	1440	168	303	166	401	**7959**
12/12/2000	1019	5749	2016	756	436	228	259	**10463**
12/13/2000	1043	5160	2592	2196	667	180	333	**12171**
12/14/2000	812	5418	2832	2052	612	252	443	**12421**
12/15/2000	543	4692	1632	1512	496	384	852	**9727**
11/18/2000	518	3682	1008	756	254	636	396	**7250**
11/19/2000	646	4422	1134	1080	411	394	534	**8621**
11/20/2000	120	5536	1152	1800	356	769	450	**10183**
11/21/2000	*0	4637	2568	2328	214	612	*0	**10359**
11/22/2000	*0	4393	1440	2532	*0	*0	*0	**8365**
12/25/2000	*0	*0	*0	*0	*0	*0	*0	**0**
12/26/2000	*0	*0	*0	*0	*0	*0	*0	**0**
12/27/2000	*0	3342	*0	*0	*0	*0	*0	**3342**
12/28/2000	*0	2304	*0	*0	*0	*0	*0	**2304**
12/29/2000	*0	1708	*0	*0	*0	*0	*0	**2304**
1/2/2001	0	1708	1728	2712	214	612	651	**7625**
1/3/2001	707	3432	528	1704	483	666	822	**8342**
1/4/2001	1379	3747	1543	144	420	280	1032	**8545**
1/5/2001	1540	3814	1632	24	574	136	724	**8308**
1/8/2001	1186	2932	1444	84	756	259	924	**7585**
1/9/2001	546	2311	1512	240	428	300	720	**6057**
1/10/2001	749	2861	1872	300	315	228	673	**6998**
1/11/2001	1064	3619	1944	276	65	208	717	**7893**
1/12/2001	1243	5325	960	928	209	312	264	**8929**
1/15/2001	1477	6366	1800	780	448	264	762	**11897**
1/16/2001	1162	5162	1152	0	413	418	474	**8781**
1/17/2001	966	4284	1152	168	154	396	438	**7558**
1/18/2001	1047	5640	1172	1512	103	384	307	**10165**
1/19/2001	1000	6215	2304	1968	164	300	694	**12345**
1/22/2001	910	3636	2804	1716	98	384	570	**10118**
1/23/2001	742	3590	1440	444	104	444	952	**7716**
1/24/2001	929	3883	1008	672	272	348	744	**7856**
1/25/2001	364	4707	1512	1824	276	408	1166	**10257**

Appendix E: Daily Levels of FLC/FSC at Empty Pallet Compounds

Date	Cologne	Genk	Saarlouis	Valencia	Dagenham	Halewood	Southampton	TOTAL
1/26/2001	245	5834	2692	2136	498	504	836	**12241**
1/29/2001	1063	5958	2544	1680	468	252	963	**12928**
1/30/2001	1428	5051	2304	1860	586	307	457	**11993**
1/31/2001	1246	5946	2320	2088	533	300	310	**12743**
2/1/2001	1130	5233	2016	1044	181	408	336	**10348**
2/2/2001	933	5159	1820	1396	277	395	450	**10035**
2/5/2001	1002	3951	1900	1224	110	504	612	**9303**
2/6/2001	707	3273	2394	1848	37	536	516	**9311**
2/7/2001	554	4857	3046	1836	50	500	719	**11562**
2/8/2001	553	4904	1992	1164	27	444	750	**9834**
2/9/2001	925	4979	2064	852	89	262	951	**9860**
2/12/2001	1327	4648	2138	936	0	240	920	**10209**
2/13/2001	1167	2814	2016	1260	28	488	572	**8345**
2/14/2001	1021	1988	2546	1668	52	288	430	**7993**
2/15/2001	846	1864	1440	2040	56	348	612	**7206**
2/16/2001	1104	1502	1662	1008	324	276	486	**6086**
2/19/2001	1375	2567	2100	1044	315	289	433	**8123**
2/20/2001	979	2923	1039	828	397	396	426	**6988**
2/21/2001	864	2883	1240	1440	570	402	463	**7862**
2/22/2001	1188	2382	2178	1380	342	252	108	**7830**
2/23/2001	1470	2742	2410	1260	415	354	500	**7830**
2/26/2001	*	1916	*	1704	700	424	356	**8980**
2/27/2001	1340	2955	3068	1116	732	332	700	**10243**
2/28/2001	1463	2884	2208	1092	562	320	722	**9251**
3/1/2001	1400	3014	1002	1524	338	348	856	**8482**
3/2/2001	1239	2156	1342	1488	555	444	512	**7736**
3/5/2001	1232	528	2190	1008	802	564	756	**7080**
3/6/2001	756	1135	1392	672	771	336	679	**5741**
3/7/2001	712	1998	1728	576	732	288	823	**6857**
3/8/2001	588	1257	2678	1152	497	97	756	**7025**
3/9/2001	994	1418	2458	1368	504	209	600	**7342**
3/12/2001	1457	1730	2676	648	582	348	666	**8107**
3/13/2001	1311	1704	1575	756	478	152	426	**6402**
3/14/2001	927	1884	1476	420	560	282	720	**6269**

Appendix E: Daily Levels of FLC/FSC at Empty Pallet Compounds

Date	Cologne	Genk	Saarlouis	Valencia	Dagenham	Halewood	Southampton	TOTAL
3/15/2001	985	2304	1903	864	419	264	803	**7542**
3/16/2001	463	2127	1098	960	400	324	776	**5824**
3/19/2001	1532	1972	2099	960	194	336	688	**7781**
3/20/2001	1628	2167	1150	888	268	407	694	**7202**
3/21/2001	1463	1971	850	168	486	360	524	**5822**
3/22/2001	1694	2617	1300	516	426	445	690	**7688**
3/23/2001	1314	2203	2516	1476	442	252	679	**8630**
3/26/2001	2072	1790	2654	1308	354	305	715	**9198**
3/27/2001	2156	2322	2558	720	378	212	530	**8876**
3/28/2001	1834	1629	1526	312	543	300	270	**6414**
3/29/2001	1185	1182	2662	96	527	384	18	**6054**
3/30/2001	1295	999	2360	564	532	372	360	**6110**
4/2/2001	1700	1452	2565	504	555	480	700	**7956**
4/3/2001	1577	1098	3464	1140	468	576	144	**8467**
4/4/2001	1410	1727	3252	1416	472	260	132	**8669**
4/5/2001	1358	1279	2468	1824	527	300	36	**7792**
4/6/2001	1461	1891	1617	960	505	163	114	**6548**
4/9/2001	757	195	2924	1104	230	228	198	**5636**
4/10/2001	901	2266	2422	996	272	336	39	**7232**
4/11/2001	423	1765	3676	792	385	288	36	**7365**
4/12/2001	644	2427	3606	468	468	216	191	**8020**
4/13/2001	644	2806	3606	468	468	216	191	**8183**
4/16/2001	644	2806	3606	468	468	216	191	**8399**
4/17/2001	1106	2241	4295	1068	619	216	480	**10025**
4/18/2001	920	2291	2608	372	414	153	493	**7251**
4/19/2001	816	2522	2886	0	451	144	462	**7281**
4/20/2001	901	1842	3112	1080	494	204	300	**7729**
4/23/2001	1283	4297	1980	2088	472	196	690	**7496**
4/24/2001	985	601	1830	1596	366	156	392	**5926**
4/25/2001	803	1858	1994	1536	530	216	344	**7281**
4/26/2001	973	1890	2140	1716	474	204	764	**8161**
4/27/2001	*	*	*	1260	231	108	672	**7687**
4/30/2001	0	0	0	1428	386	110	980	**2904**
5/1/2001	1306	2130	2088	0	460	184	612	**6780**

Appendix E: Daily Levels of FLC/FSC at Empty Pallet Compounds

Date	Cologne	Genk	Saarlouis	Valencia	Dagenham	Halewood	Southampton	TOTAL
5/2/2001	1043	2372	1380	1284	193	252	908	**7432**
5/3/2001	1093	2539	1770	1248	378	180	546	**7754**
5/4/2001	1312	2413	3188	1164	446	264	618	**9141**
5/7/2001	1652	1314	3788	1692	*	*	*	**9774**
5/8/2001	1969	543	3503	1008	504	348	740	**8615**
5/9/2001	1714	1828	3274	480	592	288	805	**8981**
5/10/2001	1113	2742	3332	948	432	96	494	**9157**
5/11/2001	1627	2170	4093	2628	362	168	24	**10904**
5/14/2001	1621	1942	3986	4332	370	204	360	**12815**
5/15/2001	1524	1440	3020	4144	164	252	532	**11076**
5/16/2001	1206	2064	2586	2328	50	264	432	**8930**
5/17/2001	1389	2603	1662	1032	354	188	294	**7522**
5/18/2001	1500	1976	680	636	678	156	24	**7522**
5/21/2001	1419	1811	1742	3024	661	156	300	**9113**
5/22/2001	889	2699	2132	2052	768	204	13	**8757**
5/23/2001	639	1639	1918	1992	501	144	336	**7169**
5/24/2001	*	*	*	1812	598	216	312	**7134**
5/25/2001	*	*	*	1908	566	240	252	**6922**
5/28/2001	861	1869	1220	996	566	240	252	**6004**
5/29/2001	1302	2690	1607	648	296	216	492	**7251**
5/30/2001	1204	2833	1539	576	404	252	384	**7192**
5/31/2001	1833	3464	1776	1128	568	276	636	**9681**

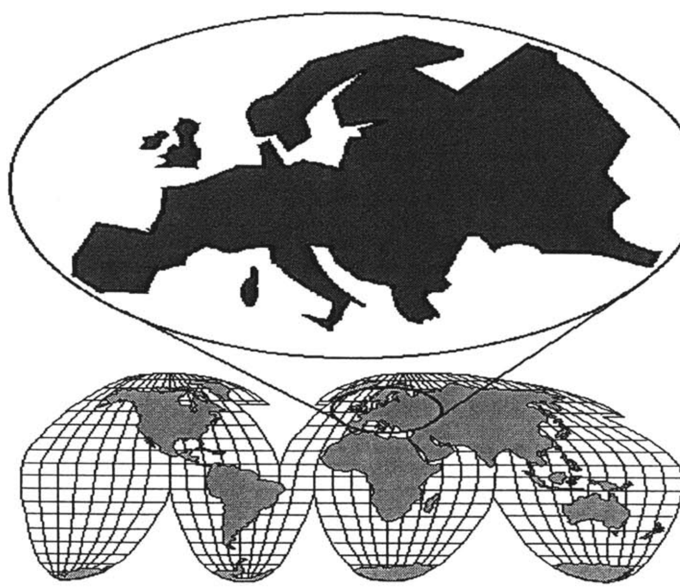
* = Plant Closed

Appendix F

Packaging Guidelines

For Externally Purchased Parts

Vehicle Operations - Europe



April 2000

EU1750

Guidelines Application

This packaging guideline is only applicable to the components that are shipped from European suppliers to the following plants:

1F, 1Y	Cologne	Body and Assembly Operations
2B,2C	Genk	Body and Assembly Operations
3B,3C	Saarlouis	Body and Assembly Operations
V2,V5	Valencia	Body and Assembly Operations
HD,ZD	Dagenham	Body and Assembly Operations
HF,ZF	Halewood	Body and Assembly Operations
ZS	Southampton	Body and Assembly Operations

For components being packed for export operations, the packaging should be expendable packaging in accordance with International Export Operations Packaging Guidelines, EU1750E.

Supplier Responsibility

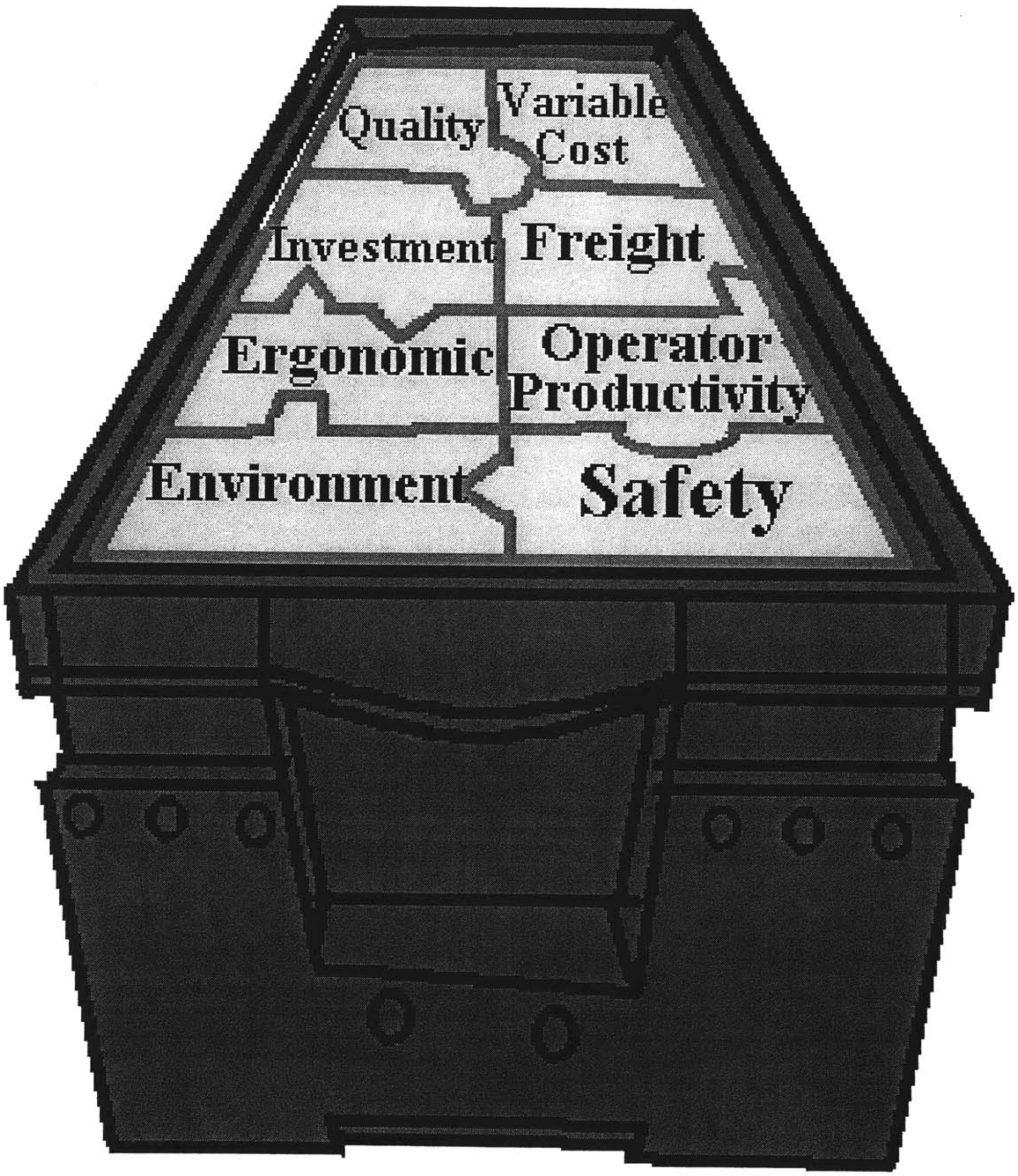
- The supplier is responsible for product quality from their manufacturing source to the point of use (linefeed at the assembly line)
- The supplier is responsible for the design and development and procurement (where appropriate) of packaging concepts, and establishing approval from the customer plant. For unique containers approval is also required from Ford Packaging Engineering
- All packaging should be developed in accordance with the relevant guideline, QS9000 Quality Systems and Purchase Order Terms and Conditions
- As part of the Ford Policy of continuous improvement, alterations to the approved pack may be requested by the receiving plants. Suppliers are required to respond quickly to these requests, and manage the packaging change. In addition, Suppliers are expected to investigate opportunities to improve the packaging design, with particular focus on improvements for the Ford production operator
- All packaging containing hazardous material must have the appropriate regulatory labeling
- All business must be quoted in compliance with these guidelines, with breakdown of packaging costs (durable / expendable dunnage costs where applicable)
- Once a packaging specification has been established, the supplier must continue to use the required pack, unless otherwise directed by Ford Packaging Engineering or the receiving plant
- The supplier is responsible for the updating of packaging data, through completion of an EU1121 Packaging Data Form, and submitting to the Ford Packaging Engineer at the receiving plant for approval. Contacts are listed in Appendix 1
- In all correspondence with Packaging Engineering, ensure that full contact details are provided, including Vendor Code

Ford's Environmental Commitment

Ford is committed to protecting the environment at every stage of the production process including transportation of parts to the assembly plants. For this reason packaging must be designed with respect to the following objectives:

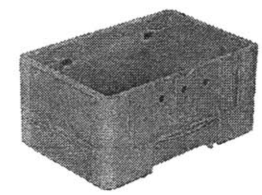
- Use durable packaging
- Use a minimum of internal expendable packaging
- Use only expendable materials which can be recycled
- All plastics (expendable & durable) must be marked with the material identification symbol to aid recycling (Appendix 5)
- To minimise transport cube

Packaging Considerations



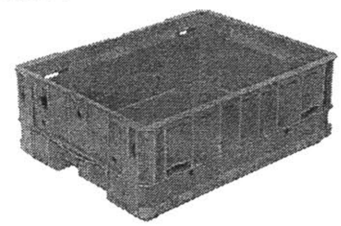
3.1 Ford Standard Container Range

KLT 3214



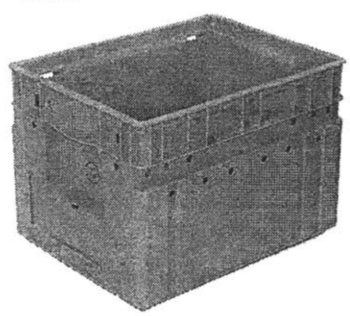
Exterior dimensions: 300 x 200 x 147mm
Internal dimensions: 271 x 136 x 130mm*
Tare weight: 0.72Kg
Manual handling capacity: 15Kg (gross)
Number of KLT per pallet: 60

KLT 4314



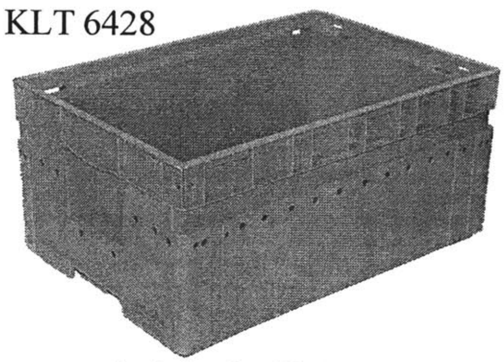
Exterior dimensions: 400 x 300 x 147mm
Internal dimensions: 334 x 247 x 103mm*
Tare weight: 1.63Kg
Manual handling capacity: 15Kg (gross)
Number of KLT per pallet: 60

KLT 4328



Exterior dimensions: 400 x 300 x 281mm
Internal dimensions: 334 x 247 x 236mm*
Tare weight: 2.6Kg
Manual handling capacity: 15Kg (gross)
Number of KLT per pallet: 30

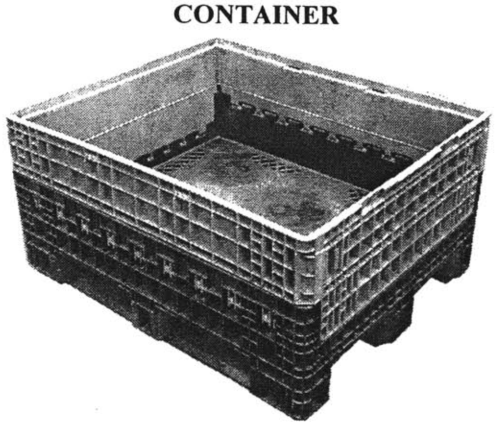
KLT 6428



Exterior dimensions: 600 x 400 x 281mm
Internal dimensions: 532 x 346 x 231mm*
Tare weight: 4.4Kg
Manual handling capacity: 15Kg (gross)
Number of KLT per pallet: 15

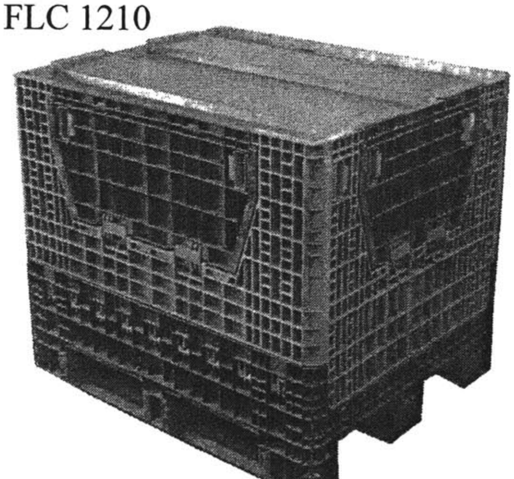
FSC 1206

SPECIAL EXCEPTION CONTAINER



Exterior dimensions erected: 1200 x 1000 x 600mm
folded: 1200 x 1000 x406mm*
Internal dimensions: 1115 x 915 x 370mm
Maximum Net load capacity: 500Kg

FLC 1210

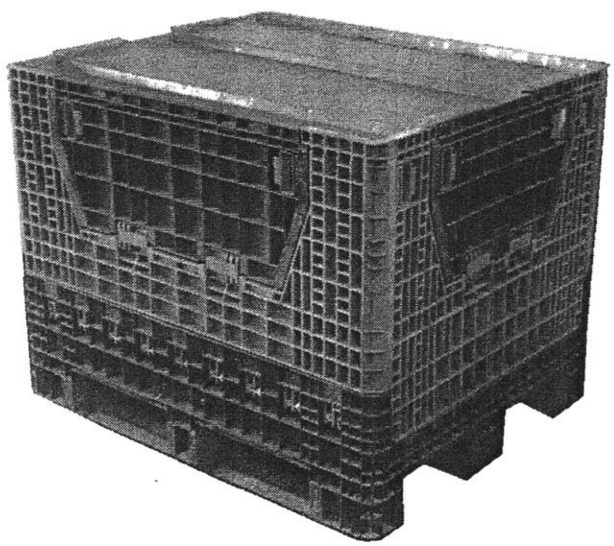


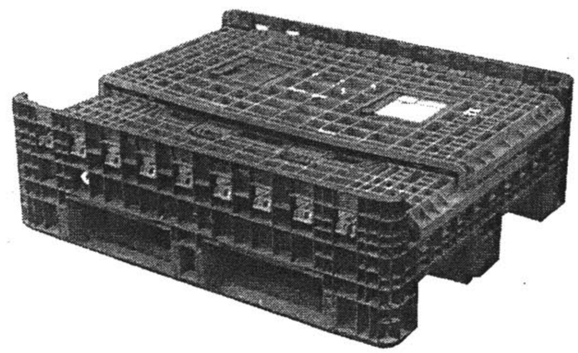
Exterior dimensions erected: 1200 x 1000 x 975mm
folded: 1200 x 1000 x 406mm*
Internal dimensions: 1115 x 915 x 755mm
Maximum Net load capacity: 500Kg

*NOTE: All dimensions given are nominal, please contact container manufacturer for exact specification

10. FLC / FSC User Guide

The FLC 1210 (Folding Large Container) is a unit load sized (1200 x 1000 x 975mm) container with drop-down access doors on two adjacent sides. The FSC (Folding Small Container) shares a common base, with a reduced overall height (1200 x 1000 x 595mm), and no access doors. Both containers fold, improving cube utilisation for the return journey. In addition to the containers, there is a separate dust cover which can be fitted to both containers. (Note - this cover is not load-bearing). For full dimensional information, refer to Appendix 3.





10.1 FLC / FSC Internal Packaging

- DO ensure that part quality is maintained using the minimum of internal packaging
- DO ensure that it is not possible for parts to tangle during transportation (consider banding parts together to minimise the risk).
- DO ensure that all expendable dunnage is recyclable (see section 13 for more information)
- DO pack containers to utilize at least 95% of internal volume
- DO ensure that container selection complies with the flow chart in section 3.2
- DO avoid using plastic bags whenever possible (consider using inter-woven foam layer pads)

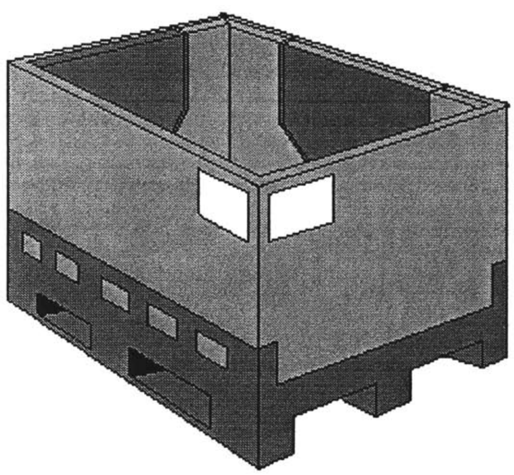
- DO NOT exceed 500kg net weight of container
- DO NOT mix different part numbers within the same container without written permission from Packaging Engineering

10.2 FLC / FSC / Odette Container Labeling Requirements

Container labels are based on the current Odette standard, printed on white weather resistant paper of weight 160-170g/m^2 with black text. These printed labels must be to latest MP&L requirements, and must include ILVS (In-Line Vehicle Sequencing) and 'Control Item' marking where appropriate. Please refer to the MP&L contact person shown in Appendix 1 for further information.

- DO use a minimum of two Odette labels, on adjacent sides of the container
- DO locate "A5" sized Odette label in label holder provided

- DO NOT use self adhesive Odette labels



Sketch showing correct positioning for labels applied to FLC container

10.3 FLC / FSC Operating Details

- DO ensure that all containers are clean, serviceable and free from redundant labels, prior to loading
- DO report complaints to your 3rd Party contact if received containers are in an unacceptable condition.
- DO ensure the lugs clip into dedicated location points in the container when fitting the dust cover to the containers
- DO develop and ensure 3 shipments worth of an emergency expendable pack is always available. This must mirror the FLC / FSC in size, pack density and stackability. Refer to guidelines in section 12.

- DO NOT floor stack containers more than 5 high
- DO NOT use any form of banding on the container

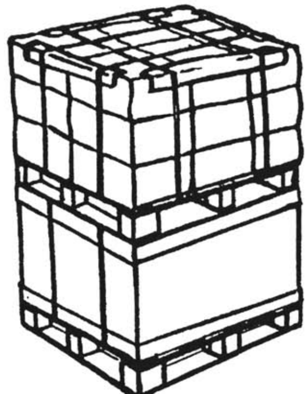
13. Emergency Expendable Packaging User Guide

Expendable packaging is **only** to be used for emergency shipments when the durable containers are not available due to unforeseen circumstances. **Internal packaging** can be expendable for standard containers.

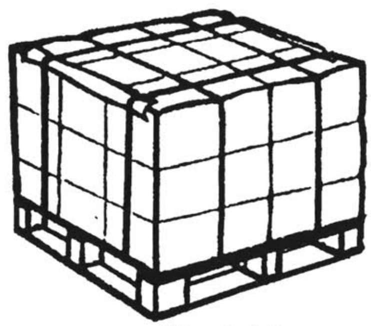
It is essential that an emergency expendable packaging solution is developed and 3 shipments worth are always available at the supplier location. **<u>THE EMEGENCY EXPENDABLE PACKAGING MUST EXACTLY REPLICATE THE DURABLE SOLUTION IN SIZE, PACK DENSITY AND STACKABILITY</u>** (refer to Appendix 3 for durable container dimensions). This is absolutely mandatory since the part ordering and external and internal logistics systems are based specifically on the container size and part quantity. Under no circumstances should emergency expendable packaging be used to ship production material to markets outside Europe.

ACCEPTABLE

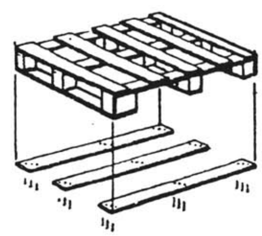
UNACCEPTABLE



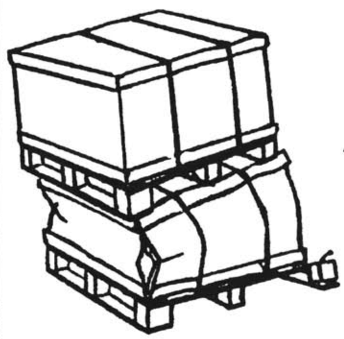
Able to safely stack in storage and transit to same height as durable equivalent



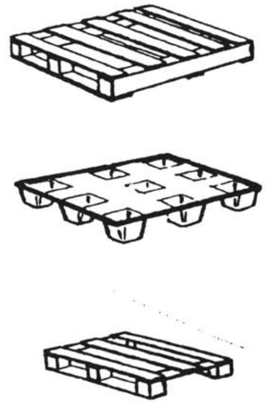
Max. height 1,000mm



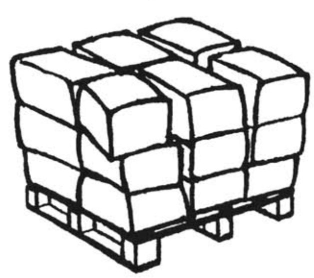
Full Perimeter pallet



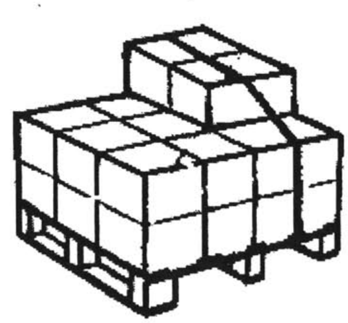
Collapsed stack



Two way entry Fibre pallet



No banding



Pyramid load

13. Emergency Expendable Packaging User Guide continued ...

- DO develop and ensure 3 shipments worth of emergency expendable packaging is available. This must mirror the durable solution in pack size, parts per pack and stackability. Hence the pack must be robust enough to enable it to be stacked to the same height in transport as the durable equivalent and to withstand the journey
- DO only use expendable external packaging in an emergency when no durable containers are available and after contact with the receiving plant
- DO make all packaging into unit loads (Fork liftable packaging units)
- DO make unit loads flat topped. Incomplete layers (pyramid loads) are not allowed
- DO label all emergency expendable packaging clearly stating that the pack is emergency packaging
- DO use banding or strapping made of plastic
- DO use pallets made of solid wood and of the four way entry type.
- DO always use full perimeter expendable pallets (see drawing on previous page)
- DO NOT use steel banding as it is difficult to remove and can cause injury.
- DO NOT use shrink wrap or stretch wrap without written permission from the local Material Handling Engineer. Ford plant fire regulations do not permit this practice.
- DO NOT allow cardboard packaging to overhang the pallet, it does not stack properly and is likely to get damaged.
- DO NOT use paper board, moulded chip or plastic expendable pallets.
- DO NOT staple the cardboard to the base pallet

13.1 Emergency Expendable Material Selection Guide

When selecting expendable material for use in emergency packs, or internal dunnage, ensure that all national legislation is adhered to. The Ford preferred materials are as follows;

Timber:

- must be untreated, natural solid wood.
- fibreboard, chipboard etc. are not allowed.
- no additional coatings or preservatives are permitted.
- must not have plastic foil adhered to it.

Paper, cardboard:

- must not include additives in the raw paper or board.
- materials used for waterproofing, impregnation, gluing etc. must not inhibit re-cycling.

Plastic Sheets and Foils:

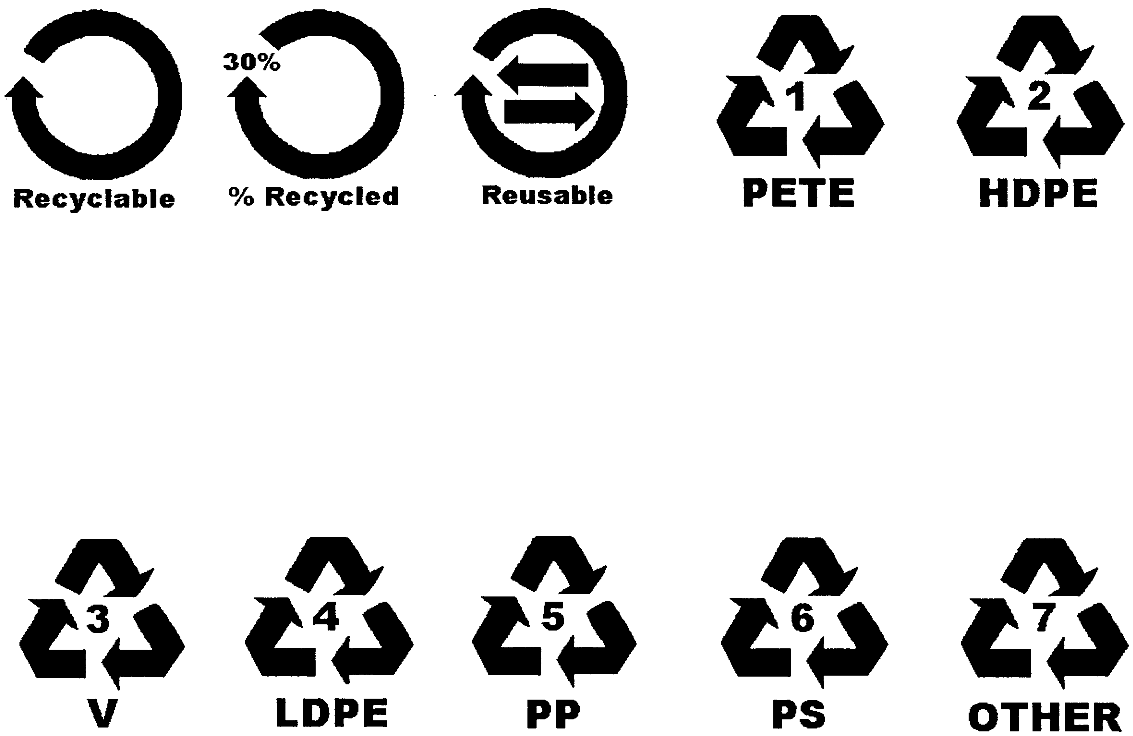
- use polyethylene, polypropylene or ABS
- where printed the surface area of the ink must not exceed 3% total surface.
- adhesive tapes and stickers should be polyethylene or polypropylene.

Appendix 3 Standard Container Details

Code	External Dimensions mm	Internal Dimensions mm	Folded Height mm	Tare Weight (empty)	Max Gross Weight (inc container)
Ford Owned Steel Containers					
ZE49	2200 x 1200 x 1010	2065 x 1130 x 705	450	270 kg	2000 kg
ZE39	2200 x 1200 x 1010	2065 x 1130 x 705	Rigid	241 kg	2000 kg
ZE39X *	2200 x 1200 x 1010	2080 x 1200 x 735	Rigid	136 kg	2000 kg
ZE38	1200 x 1000 x 1010	1130 x 835 x 705	Rigid	180 kg	2000kg
ZE38X *	1200 x 1000 x 1010	1200 x 880 x 723	Rigid	105 kg	2000kg
ZE29	2500 x 1200 x 1010	2365 x 1130 x 705	Rigid	245 kg	2000 kg
ZE29X *	2500 x 1200 x 1010	2380 x 1200 x 735	Rigid	140 kg	2000 kg
ZE15	1200 x 1000 x 1000	1130 x 930 x 800	330	106 kg	1000 kg
OD8424	1600 x 1200 x 1000	1530 x 1130 x 806	400	180 kg	1500 kg
OD8402	1200 x 1000 x 1000	1130 x 930 x 806	400	145 kg	1000 kg
OD8401	1200 x 1000 x 750	1130 x 930 x 556	300	127 kg	1000 kg
UZE5	1200 x 1000 x 760		Rigid	160 kg	3000 kg
** X - End posts only - No mesh sides*					
Ford Owned Semi-Durable Containers - (Unipaks)					
S1210	1200 x 1000 x 975	1135 x 935 x 755	385	30 kg	500 kg
S1206	1200 x 1000 x 600	1135 x 935 x 380	385	26 kg	500 kg
S1205	1200 x 1000 x 500	1135 x 935 x 280	385	24 kg	500 kg
S1610	1600 x 1200 x 1000	1530 x 1130 x 795	385	43 kg	500 kg
S1607	1600 x 1200 x 750	1530 x 1130 x 545	385	39 kg	500 kg
Third Party Owned Modular Containers					
FLC 1210	1200 x 1000 x 975	1115 x 915 x 757	410	63 kg	563 kg
FSC 1206	1200 x 1000 x 595	1115 x 915 x 382	410	40 kg	540 kg
KLT 6428	600 x 400 x 280	532 x 346 x 231	Rigid	4.4 kg	15 kg
KLT 4328	400 x 300 x 280	334 x 247 x 236	Rigid	2.6 kg	15 kg
KLT 4314	400 x 300 x 140	334 x 247 x 104	Rigid	1.6 kg	15 kg
KLT 3214	300 x 200 x 140	271 x 136 x 130	Rigid	0.7 kg	15 kg
PB1 / L1	1200 x 1000 x 144	Pallet & Lid	Rigid	28 kg	1500 kg
PB2 / L2	1000 x 600 x 144	Pallet & Lid	Rigid	14 kg	500 kg

Appendix 5

Recycling and Plastics Identification Symbols



Sources:

Recycling symbols are those proposed by European Union

Plastics Identification codes are those devised by the Society of Plastics Industry (SPI) in USA

1. **Polyethylene Terphthalate**
2. **High Density Polyethylene**
3. **Polyvinyl Chloride (PVC)**
4. **Low Density Polyethylene**
5. **Polypropylene**
6. **Polystyrene**
7. **Other**

All financial data and costs are competitive market prices and not actual Ford costs.

Shipping

Competitive Market Transportation Costs per Empty FLC

	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	€ 10.38	€ 4.51	€ 11.85	€ 3.82	€ 3.73	€ 10.97	€ 15.62
France	€ 5.54	€ 2.15	€ 5.68	€ 2.65	€ 2.15	€ 4.80	€ 7.99
Hungary	€ 15.18	€ 7.01	€ 16.65	€ 6.32	€ 6.22	€ 15.76	€ 15.62
Italy	€ 9.30	€ 5.05	€ 10.77	€ 4.46	€ 3.37	€ 9.89	€ 7.63
Netherlands	€ 6.09	€ 0.98	€ 4.90	€ 1.37	€ 2.37	€ 4.01	€ 9.81
Poland	€ 13.71	€ 6.86	€ 15.18	€ 6.23	€ 7.13	€ 14.30	€ 17.44
Portugal	€ 14.20	€ 11.75	€ 15.67	€ 12.31	€ 11.70	€ 14.78	€ 5.72
Slovakia	€ 13.71	€ 6.01	€ 15.18	€ 5.32	€ 5.45	€ 14.30	€ 16.35
Sweden	€ 9.89	€ 8.43	€ 10.57	€ 8.13	€ 9.25	€ 10.87	€ 23.00
Switzerland	€ 7.15	€ 3.26	€ 8.62	€ 2.67	€ 1.57	€ 7.74	€ 9.44
Belgium	€ 4.76	€ 0.12	€ 4.90	€ 0.56	€ 1.67	€ 4.01	€ 9.08
Germany	€ 4.90	€ 2.36	€ 6.36	€ 1.86	€ 1.43	€ 5.48	€ 12.71
United Kingdom	€ 3.88	€ 4.87	€ 3.93	€ 5.32	€ 6.43	€ 4.20	€ 16.35
Spain	€ 11.75	€ 9.57	€ 13.22	€ 9.34	€ 8.43	€ 12.34	€ 0.81

Demand Jun-00 through May-01

Total Demand

Annual Movements	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
	124,131	699,353	36,665	249,412	889,540	121,268	574,285
Total Movements for Europe	2,694,654						

German and Belgium Demand

Ford Code		DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA	Subtotals
N2KUA	BELGIUM	0	7,928	54	175	18,032	0	8,719	34,908
P68PA	BELGIUM	0	691	0	0	60,055	0	385	61,131
S3EWF	BELGIUM	0	3,111	0	0	1,789	0	874	5,774
0098A	GERMANY	3,490	1,848	902	6,720	11,769	0	8,880	33,609
B45XB	GERMANY	1,074	25,862	125	2,397	2,415	2,007	981	34,861
B45XC	GERMANY	1,758	12,354	1	3,420	38	0	0	17,571
B492A	GERMANY	205	232	106	457	0	1	287	1,288
C65ZA	GERMANY	19	0	0	38	0	0	0	57
C66LA	GERMANY	340	259	0	2	1,625	2	24	2,252
C7C3A	GERMANY	0	0	163	0	0	0	0	163
C7G0A	GERMANY	0	0	0	34	0	0	2,339	2,373
C85HA	GERMANY	0	0	0	595	0	0	0	595
C86HA	GERMANY	0	617	0	0	1,761	0	870	3,248

A	B	C	D	E	F	G	H	I	J	K	L	M
44	C8L6A	GERMANY	0	819	0	0	0	0	0	819		
45	C95YA	GERMANY	1	384	66	0	0	0	0	451		
46	C99ZA	GERMANY	0	0	0	144	0	154	0	298		
47	C9E5B	GERMANY	0	1,916	0	0	0	0	0	1,916		
48	C9H7A	GERMANY	0	3,862	0	0	0	0	0	3,862		
49	C9J8A	GERMANY	69	98	2	0	8	100	0	277		
50	C9N9A	GERMANY	0	0	0	2	8,407	8	4,393	12,810		
51	CF334	GERMANY	5,223	24,595	0	12,458	27	0	0	42,303		
52	D05WA	GERMANY	103	2,886	1	270	1,031	0	590	4,881		
53	D0BQA	GERMANY	0	191	0	11	321	0	185	708		
54	D0N0C	GERMANY	0	17	0	3	7,866	0	3,241	11,127		
55	D0PRE	GERMANY	10	19,099	485	0	20,044	2,111	9,962	51,711		
56	D0SCA	GERMANY	0	0	0	366	0	19	0	385		
57	D14CC	GERMANY	0	0	0	0	0	0	673	673		
58	D14CD	GERMANY	286	1,445	0	48	1	0	0	1,780		
59	D14CG	GERMANY	2,565	12	0	5,230	25	0	0	7,832		
60	D15ZA	GERMANY	0	0	0	0	0	0	655	655		
61	D1T8A	GERMANY	0	295	0	0	0	0	0	295		
62	D25KD	GERMANY	4,696	6,077	0	10,900	96	2,662	3,268	27,699		
63	D29JA	GERMANY	166	396	0	409	265	0	128	1,364		
64	D2G0A	GERMANY	1,033	0	0	1,656	0	2	0	2,691		
65	D2H1A	GERMANY	29	4,793	0	0	0	0	0	4,822		
66	D31QA	GERMANY	22	1,743	0	96	0	0	0	1,861		
67	D33MA	GERMANY	0	36	0	0	1,802	0	901	2,739		
68	D33QB	GERMANY	705	0	0	1,185	0	1	1	1,892		
69	D37YA	GERMANY	0	0	0	0	1,555	0	0	1,555		
70	D3B5A	GERMANY	0	5,396	0	26	200	0	0	5,622		
71	D3L4A	GERMANY	50	0	0	84	1,237	0	632	2,003		
72	D797B	GERMANY	385	89	0	0	3,596	47	1,231	5,348		
73	E510D	GERMANY	6	2,593	0	0	1,546	0	265	4,410		
74	F488A	GERMANY	0	335	0	0	0	0	0	335		
75	F4SWE	GERMANY	0	3,254	0	5	0	984	0	4,243		
76	H248X	GERMANY	2,603	2	1,042	5,243	0	2	1,498	10,390		
77	I053A	GERMANY	382	0	0	981	0	28	0	1,391		
78	J613A	GERMANY	702	0	0	1,892	0	9	0	2,603		
79	M738A	GERMANY	568	5,264	168	921	7,636	0	5,273	19,830		
80	M738C	GERMANY	1	0	0	496	1,296	0	505	2,298		
81	N3TGA	GERMANY	0	0	0	0	4,337	0	1,291	5,628		
82	P108A	GERMANY	0	0	0	4	1,170	0	475	1,649		
83	S004A	GERMANY	395	762	0	731	4,668	0	1,383	7,939		
84	S3EWE	GERMANY	0	2,605	2	0	6,518	0	3,488	12,613		
85	S3EWT	GERMANY	1	1,383	1	0	0	50	0	1,435		

A	B	C	D	E	F	G	H	I	J	K	L	M
86	S4MZA	GERMANY	0	188	0	0	0	0	0	188		
87	T4FWA	GERMANY	89	2,498	51	369	5,017	2	2,487	10,513		
88	V1JVA	GERMANY	0	342	0	0	6,595	192	2,760	9,889		
89		Belgium Subtotal	0	11,730	54	175	79,876	0	9,978	101,813		
90		German Subtotal	26,976	134,547	3,115	57,193	102,872	8,381	58,666	391,750		
91												
92												
93												
94												
95		***Spanish Demand***										
96	Ford Code		DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA	Subtotals		
97	A910A	SPAIN	0	0	0	0	0	0	1,064	1,064		
98	AK2HA	SPAIN	0	0	0	0	0	0	76,389	76,389		
99	AQ7VA	SPAIN	161	0	0	380	0	3	239	783		
100	ATC2	SPAIN	0	1,997	0	0	4,373	0	2,184	8,554		
101	BGDXA	SPAIN	0	0	0	0	0	0	2,577	2,577		
102	BSB7A	SPAIN	0	0	0	0	1,554	0	812	2,366		
103	BTL54	SPAIN	0	21	0	0	3,449	0	50	3,520		
104	C6T4A	SPAIN	0	5,669	0	0	0	549	0	6,218		
105	C71WA	SPAIN	0	0	202	477	0	0	0	679		
106	C72GA	SPAIN	0	237	0	0	0	0	0	237		
107	C79MA	SPAIN	0	0	0	0	1,760	0	109	1,869		
108	C79MB	SPAIN	2,332	0	11	4,952	6,994	1	0	14,290		
109	C7Y2A	SPAIN	776	8,625	0	2,317	0	0	0	11,718		
110	C7Y2C	SPAIN	0	1,746	0	0	0	799	0	2,545		
111	C7Z2A	SPAIN	0	5,013	304	0	0	0	0	5,317		
112	C83FA	SPAIN	1,206	975	0	2,893	0	0	394	5,468		
113	C83HE	SPAIN	0	1,211	0	0	27,769	0	15,155	44,135		
114	C83HF	SPAIN	0	3	0	0	73	0	29	105		
115	C83TA	SPAIN	0	0	1,733	0	0	0	9,496	11,229		
116	C8H5A	SPAIN	0	5,105	0	0	0	2,113	4,682	11,900		
117	D0CYA	SPAIN	0	598	0	0	12,583	0	9,323	22,504		
118	D0D1A	SPAIN	3,040	10,098	581	7,524	98	25	7,083	28,449		
119	D0D2A	SPAIN	474	1,514	0	960	0	0	2,010	4,958		
120	D0D2A.	SPAIN	1	8	0	4	9	0	10	32		
121	D0ENA	SPAIN	0	2,517	0	2	562	1,528	747	5,356		
122	D0NZA	SPAIN	0	0	0	0	5,699	0	2,845	8,544		
123	D0TAA	SPAIN	729	1,670	78	1,507	273	4	515	4,776		
124	D0XFA	SPAIN	0	2,054	9	0	0	0	0	2,063		
125	D11BE	SPAIN	724	4,158	266	1,501	2,896	0	2,137	11,682		
126	D1M2A	SPAIN	169	262	14	562	0	0	173	1,180		
127	D1M2A	SPAIN	2,126	7,698	281	5,962	0	140	2,983	19,190		
128	D252A	SPAIN	0	619	0	0	2	145	788	1,554		

A	B	C	D	E	F	G	H	I	J	K	L	M
129	D26ZA	SPAIN	0	3	0	0	0	0	266	269		
130	D2A3A	SPAIN	0	9,225	0	0	4,024	4,768	9,053	27,070		
131	D2A3B	SPAIN	0	0	0	0	2,272	0	0	2,272		
132	D38MA	SPAIN	1,350	114	225	2,553	0	62	5,221	9,525		
133	D38MB	SPAIN	300	0	0	1,048	0	0	0	1,348		
134	D3C6C	SPAIN	0	0	0	0	0	0	644	644		
135	D3K7A	SPAIN	0	0	0	0	0	0	356	356		
136	D3L5A	SPAIN	0	2,497	0	102	1,871	0	1	4,471		
137	E18QA	SPAIN	1,665	0	0	4,114	0	0	10	5,789		
138	H1XPA	SPAIN	0	5,839	0	2,358	9,353	2,735	6,454	26,739		
139	K18BC	SPAIN	0	4,950	0	0	0	0	456	5,406		
140	K261A	SPAIN	1,289	0	265	2,332	5,856	24	34	9,800		
141	K3D6A	SPAIN	603	1,644	0	651	0	0	2,042	4,940		
142	K8N7A	SPAIN	2,654	144	559	3,429	0	0	1,538	8,324		
143	L0BMA	SPAIN	704	45	0	1,142	17,850	0	8,645	28,386		
144	L8SFA	SPAIN	0	0	0	0	0	0	332	332		
145	M1F4A	SPAIN	0	0	0	0	125	0	103	228		
146	M1F4A	SPAIN	0	0	10	0	1,016	0	689	1,715		
147	M1F4B	SPAIN	0	5	0	0	10,455	2	7,062	17,524		
148	P4FPA	SPAIN	0	801	0	0	4	0	1	806		
149	P6U6A	SPAIN	10	0	0	797	0	0	0	807		
150	P8TWA	SPAIN	1	214	0	0	0	76	0	291		
151	P9Z1A	SPAIN	0	14	0	0	0	0	5,293	5,307		
152	R1K8A	SPAIN	0	7,014	0	0	0	2,904	81	9,999		
153	R4F2A	SPAIN	326	0	0	698	0	1	0	1,025		
154	R76JA	SPAIN	0	0	0	0	0	0	1,354	1,354		
155	R8KXA	SPAIN	0	3,007	0	1	0	1,520	0	4,528		
156	R8VLA	SPAIN	0	71	0	0	0	25	0	96		
157	S0OSCA	SPAIN	0	0	0	0	0	0	3,129	3,129		
158	S9E0B	SPAIN	5	6,942	1,062	0	0	0	0	8,009		
159	T53CA	SPAIN	84	1,283	0	0	9,896	0	3,395	14,658		
160	T53CC	SPAIN	0	6,354	0	0	0	0	0	6,354		
161	T5USA	SPAIN	0	4,034	0	0	1,175	2,447	490	8,146		
162	T655C	SPAIN	0	0	0	0	0	0	7	7		
163	T655D	SPAIN	0	0	0	0	0	0	241	241		
164	U9DCA	SPAIN	0	185	0	1	0	11	0	197		
165	U9DMA	SPAIN	10	0	0	2,201	0	0	21	2,232		
166	V0J2C	SPAIN	0	0	0	0	0	0	22	22		
167		Subtotals	20,739	116,183	5,600	50,468	131,991	19,882	198,734	543,597		
168												
169												

A	B	C	D	E	F	G	H	I	J	K	L	M
170		**Demand Jun-00 through May-01**										
171		***Annual Movements***	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA			
172		***Without Belgium, German, & Spanish***	76,416	436,893	27,896	141,576	574,801	93,005	306,907			
173		Total Movements for Europe	2,694,654									
174												
175												
176	**Supply Decision Variables**											**Demand Constraints**
177		***Annual Movements***	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA	Subtotals		***Annual Moves***
178		CZECH	0	0	0	0	165,685	0	0	165,685		165,685
179		FRANCE	0	191,850	0	0	223,138	0	0	414,988		414,988
180		HUNGARY	0	0	0	0	43,736	0	0	43,736		43,736
181		ITALY	0	0	0	0	113,443	0	0	113,443		113,443
182		NETHERLANDS	0	23,688	0	0	0	0	0	23,688		23,688
183		POLAND	0	0	0	14,712	0	0	0	14,712		14,712
184		PORTUGAL	0	0	0	0	0	0	21,284	21,284		21,284
185		SLOVAKIA	0	0	0	0	1,910	0	0	1,910		1,910
186		SWEDEN	0	4,979	0	0	0	0	0	4,979		4,979
187		SWITZERLAND	0	0	0	0	3,501	0	0	3,501		3,501
188		BELGIUM	0	744	0	0	0	0	0	744		744
189		GERMANY	0	0	0	0	180,664	0	0	180,664		180,664
190		UK	124,131	376,279	36,665	0	0	121,268	0	658,343		658,343
191		SPANISH	0	0	0	0	0	0	9,817	9,817		9,817
192		N2KUA	0	34,908	0	0	0	0	0	34,908		34,908
193		P68PA	0	61,131	0	0	0	0	0	61,131		61,131
194		S3EWF	0	5,774	0	0	0	0	0	5,774		5,774
195		0098A	0	0	0	0	33,609	0	0	33,609		33,609
196		B45XB	0	0	0	0	34,861	0	0	34,861		34,861
197		B45XC	0	0	0	17,571	0	0	0	17,571		17,571
198		B492A	0	0	0	1,288	0	0	0	1,288		1,288
199		C65ZA	0	0	0	57	0	0	0	57		57
200		C66LA	0	0	0	2,252	0	0	0	2,252		2,252
201		C7C3A	0	0	0	163	0	0	0	163		163
202		C7G0A	0	0	0	2,373	0	0	0	2,373		2,373
203		C85HA	0	0	0	595	0	0	0	595		595
204		C86HA	0	0	0	3,248	0	0	0	3,248		3,248
205		C8L6A	0	0	0	0	819	0	0	819		819
206		C95YA	0	0	0	451	0	0	0	451		451
207		C99ZA	0	0	0	0	298	0	0	298		298
208		C9E5B	0	0	0	0	1,916	0	0	1,916		1,916
209		C9H7A	0	0	0	3,862	0	0	0	3,862		3,862
210		C9J8A	0	0	0	277	0	0	0	277		277

A	B	C	D	E	F	G	H	I	J	K	L	M
211		C9N9A	0	0	0	12,810	0	0	0	12,810		12,810
212		CF334	0	0	0	42,303	0	0	0	42,303		42,303
213		D05WA	0	0	0	0	4,881	0	0	4,881		4,881
214		D0BQA	0	0	0	0	708	0	0	708		708
215		D0N0C	0	0	0	11,127	0	0	0	11,127		11,127
216		D0PRE	0	0	0	51,711	0	0	0	51,711		51,711
217		D0SCA	0	0	0	0	385	0	0	385		385
218		D14CC	0	0	0	0	673	0	0	673		673
219		D14CD	0	0	0	1,780	0	0	0	1,780		1,780
220		D14CG	0	0	0	0	7,832	0	0	7,832		7,832
221		D15ZA	0	0	0	655	0	0	0	655		655
222		D1T8A	0	0	0	0	295	0	0	295		295
223		D25KD	0	0	0	17,361	10,338	0	0	27,699		27,699
224		D29JA	0	0	0	1,364	0	0	0	1,364		1,364
225		D2G0A	0	0	0	0	2,691	0	0	2,691		2,691
226		D2H1A	0	0	0	4,822	0	0	0	4,822		4,822
227		D31QA	0	0	0	1,861	0	0	0	1,861		1,861
228		D33MA	0	0	0	2,739	0	0	0	2,739		2,739
229		D33QB	0	0	0	1,892	0	0	0	1,892		1,892
230		D37YA	0	0	0	0	1,555	0	0	1,555		1,555
231		D3B5A	0	0	0	5,622	0	0	0	5,622		5,622
232		D3L4A	0	0	0	0	2,003	0	0	2,003		2,003
233		D797B	0	0	0	5,348	0	0	0	5,348		5,348
234		E510D	0	0	0	0	4,410	0	0	4,410		4,410
235		F488A	0	0	0	335	0	0	0	335		335
236		F4SWE	0	0	0	0	4,243	0	0	4,243		4,243
237		H248X	0	0	0	10,390	0	0	0	10,390		10,390
238		I053A	0	0	0	1,391	0	0	0	1,391		1,391
239		J613A	0	0	0	2,603	0	0	0	2,603		2,603
240		M738A	0	0	0	0	19,830	0	0	19,830		19,830
241		M738C	0	0	0	2,298	0	0	0	2,298		2,298
242		N3TGA	0	0	0	0	5,628	0	0	5,628		5,628
243		P108A	0	0	0	1,649	0	0	0	1,649		1,649
244		S004A	0	0	0	0	7,939	0	0	7,939		7,939
245		S3EWE	0	0	0	12,613	0	0	0	12,613		12,613
246		S3EWT	0	0	0	0	1,435	0	0	1,435		1,435
247		S4MZA	0	0	0	0	188	0	0	188		188
248		T4FWA	0	0	0	0	10,513	0	0	10,513		10,513
249		V1JVA	0	0	0	9,889	0	0	0	9,889		9,889
250		A910A	0	0	0	0	0	0	1,064	1,064		1,064
251		AK2HA	0	0	0	0	0	0	76,389	76,389		76,389
252		AQ7VA	0	0	0	0	0	0	783	783		783

A	B	C	D	E	F	G	H	I	J	K	L	M
253		ATC2	0	0	0	0	0	0	8,554	8,554		8,554
254		BGDXA	0	0	0	0	0	0	2,577	2,577		2,577
255		BSB7A	0	0	0	0	0	0	2,366	2,366		2,366
256		BTL54	0	0	0	0	0	0	3,520	3,520		3,520
257		C6T4A	0	0	0	0	0	0	6,218	6,218		6,218
258		C71WA	0	0	0	0	0	0	679	679		679
259		C72GA	0	0	0	0	237	0	0	237		237
260		C79MA	0	0	0	0	0	0	1,869	1,869		1,869
261		C79MB	0	0	0	0	0	0	14,290	14,290		14,290
262		C7Y2A	0	0	0	0	0	0	11,718	11,718		11,718
263		C7Y2C	0	0	0	0	0	0	2,545	2,545		2,545
264		C7Z2A	0	0	0	0	0	0	5,317	5,317		5,317
265		C83FA	0	0	0	0	0	0	5,468	5,468		5,468
266		C83HE	0	0	0	0	0	0	44,135	44,135		44,135
267		C83HF	0	0	0	0	0	0	105	105		105
268		C83TA	0	0	0	0	0	0	11,229	11,229		11,229
269		C8H5A	0	0	0	0	0	0	11,900	11,900		11,900
270		D0CYA	0	0	0	0	0	0	22,504	22,504		22,504
271		D0D1A	0	0	0	0	0	0	28,449	28,449		28,449
272		D0D2A	0	0	0	0	176	0	4,782	4,958		4,958
273		D0D2A.	0	0	0	0	0	0	32	32		32
274		D0ENA	0	0	0	0	0	0	5,356	5,356		5,356
275		D0NZA	0	0	0	0	0	0	8,544	8,544		8,544
276		D0TAA	0	0	0	0	0	0	4,776	4,776		4,776
277		D0XFA	0	0	0	0	0	0	2,063	2,063		2,063
278		D11BE	0	0	0	0	0	0	11,682	11,682		11,682
279		D1M2A	0	0	0	0	0	0	1,180	1,180		1,180
280		D1M2A	0	0	0	0	0	0	19,190	19,190		19,190
281		D252A	0	0	0	0	0	0	1,554	1,554		1,554
282		D26ZA	0	0	0	0	0	0	269	269		269
283		D2A3A	0	0	0	0	0	0	27,070	27,070		27,070
284		D2A3B	0	0	0	0	0	0	2,272	2,272		2,272
285		D38MA	0	0	0	0	0	0	9,525	9,525		9,525
286		D38MB	0	0	0	0	0	0	1,348	1,348		1,348
287		D3C6C	0	0	0	0	0	0	644	644		644
288		D3K7A	0	0	0	0	0	0	356	356		356
289		D3L5A	0	0	0	0	0	0	4,471	4,471		4,471
290		E18QA	0	0	0	0	0	0	5,789	5,789		5,789
291		H1XPA	0	0	0	0	0	0	26,739	26,739		26,739
292		K18BC	0	0	0	0	0	0	5,406	5,406		5,406
293		K261A	0	0	0	0	0	0	9,800	9,800		9,800
294		K3D6A	0	0	0	0	0	0	4,940	4,940		4,940
295		K8N7A	0	0	0	0	0	0	8,324	8,324		8,324
296		L0BMA	0	0	0	0	0	0	28,386	28,386		28,386

A	B	C	D	E	F	G	H	I	J	K	L	M
297		L8SFA	0	0	0	0	0	0	332	332		332
298		M1F4A	0	0	0	0	0	0	228	228		228
299		M1F4A	0	0	0	0	0	0	1,715	1,715		1,715
300		M1F4B	0	0	0	0	0	0	17,524	17,524		17,524
301		P4FPA	0	0	0	0	0	0	806	806		806
302		P6U6A	0	0	0	0	0	0	807	807		807
303		P8TWA	0	0	0	0	0	0	291	291		291
304		P9Z1A	0	0	0	0	0	0	5,307	5,307		5,307
305		R1K8A	0	0	0	0	0	0	9,999	9,999		9,999
306		R4F2A	0	0	0	0	0	0	1,025	1,025		1,025
307		R76JA	0	0	0	0	0	0	1,354	1,354		1,354
308		R8KXA	0	0	0	0	0	0	4,528	4,528		4,528
309		R8VLA	0	0	0	0	0	0	96	96		96
310		S0OSCA	0	0	0	0	0	0	3,129	3,129		3,129
311		S9E0B	0	0	0	0	0	0	8,009	8,009		8,009
312		T53CA	0	0	0	0	0	0	14,658	14,658		14,658
313		T53CC	0	0	0	0	0	0	6,354	6,354		6,354
314		T5USA	0	0	0	0	0	0	8,146	8,146		8,146
315		T655C	0	0	0	0	0	0	7	7		7
316		T655D	0	0	0	0	0	0	241	241		241
317		U9DCA	0	0	0	0	0	0	197	197		197
318		U9DMA	0	0	0	0	0	0	2,232	2,232		2,232
319		V0J2C	0	0	0	0	0	0	22	22		22
320		Subtotals	124,131	699,353	36,665	249,412	889,540	121,268	574,285			
321	Total Movements for Europe		2,694,654							2,694,654		2,694,654
322												
323		**Summation Table**										
324		***Annual Movements***	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA	Subtotals		
325		CZECH	0	0	0	0	165,685	0	0	165,685		
326		FRANCE	0	191,850	0	0	223,138	0	0	414,988		
327		HUNGARY	0	0	0	0	43,736	0	0	43,736		
328		ITALY	0	0	0	0	113,443	0	0	113,443		
329		NETHERLANDS	0	23,688	0	0	0	0	0	23,688		
330		POLAND	0	0	0	14,712	0	0	0	14,712		
331		PORTUGAL	0	0	0	0	0	0	21,284	21,284		
332		SLOVAKIA	0	0	0	0	1,910	0	0	1,910		
333		SWEDEN	0	4,979	0	0	0	0	0	4,979		
334		SWITZERLAND	0	0	0	0	3,501	0	0	3,501		
335		BELGIUM	0	102,557	0	0	0	0	0	102,557		
336		GERMANY	0	0	0	234,700	337,714	0	0	572,414		
337		UK	124,131	376,279	36,665	0	0	121,268	0	658,343		
338		SPANISH	0	0	0	0	413	0	553,001	553,414		
339		Subtotals	124,131	699,353	36,665	249,412	889,540	121,268	574,285			
340			2,694,654							2,694,654		

A	B	C	D	E	F	G	H	I	J	K	L	M
341												
342												
343	**Empty Container Freight**											
344		**Empty Shipping Costs in Euros**										
345		***Annual Movements***	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA			
346		CZECH	€ -	€ -	€ -	€ -	€ 617,495	€ -	€ -			
347		FRANCE	€ -	€ 412,878	€ -	€ -	€ 478,962	€ -	€ -			
348		HUNGARY	€ -	€ -	€ -	€ -	€ 272,076	€ -	€ -			
349		ITALY	€ -	€ -	€ -	€ -	€ 382,739	€ -	€ -			
350		NETHERLANDS	€ -	€ 23,232	€ -	€ -	€ -	€ -	€ -			
351		POLAND	€ -	€ -	€ -	€ 91,686	€ -	€ -	€ -			
352		PORTUGAL	€ -	€ -	€ -	€ -	€ -	€ -	€ 121,654			
353		SLOVAKIA	€ -	€ -	€ -	€ -	€ 10,415	€ -	€ -			
354		SWEDEN	€ -	€ 41,980	€ -	€ -	€ -	€ -	€ -			
355		SWITZERLAND	€ -	€ -	€ -	€ -	€ 5,494	€ -	€ -			
356		BELGIUM	€ -	€ 86	€ -	€ -	€ -	€ -	€ -			
357		GERMANY	€ -	€ -	€ -	€ -	€ 257,801	€ -	€ -			
358		UK	€ 481,262	€ 1,833,227	€ 144,022	€ -	€ -	€ 509,455	€ -			
359		SPANISH	€ -	€ -	€ -	€ -	€ -	€ -	€ 7,990			
360		N2KUA	€ -	€ 1,956	€ -	€ -	€ -	€ -	€ -			
361		P68PA	€ -	€ 10,278	€ -	€ -	€ -	€ -	€ -			
362		S3EWF	€ -	€ 1,715	€ -	€ -	€ -	€ -	€ -			
363		0098A	€ -	€ -	€ -	€ -	€ 942	€ -	€ -			
364		B45XB	€ -	€ -	€ -	€ -	€ 118,397	€ -	€ -			
365		B45XC	€ -	€ -	€ -	€ 46,579	€ -	€ -	€ -			
366		B492A	€ -	€ -	€ -	€ 144	€ -	€ -	€ -			
367		C65ZA	€ -	€ -	€ -	€ 10	€ -	€ -	€ -			
368		C66LA	€ -	€ -	€ -	€ 5,553	€ -	€ -	€ -			
369		C7C3A	€ -	€ -	€ -	€ 12	€ -	€ -	€ -			
370		C7G0A	€ -	€ -	€ -	€ 652	€ -	€ -	€ -			
371		C85HA	€ -	€ -	€ -	€ 163	€ -	€ -	€ -			
372		C86HA	€ -	€ -	€ -	€ 4,860	€ -	€ -	€ -			
373		C8L6A	€ -	€ -	€ -	€ -	€ 1,726	€ -	€ -			
374		C95YA	€ -	€ -	€ -	€ 366	€ -	€ -	€ -			
375		C99ZA	€ -	€ -	€ -	€ -	€ 476	€ -	€ -			
376		C9E5B	€ -	€ -	€ -	€ -	€ 2,040	€ -	€ -			
377		C9H7A	€ -	€ -	€ -	€ 1,688	€ -	€ -	€ -			
378		C9J8A	€ -	€ -	€ -	€ 121	€ -	€ -	€ -			
379		C9N9A	€ -	€ -	€ -	€ 3,805	€ -	€ -	€ -			
380		CF334	€ -	€ -	€ -	€ 77,763	€ -	€ -	€ -			
381		D05WA	€ -	€ -	€ -	€ -	€ 16,085	€ -	€ -			
382		D0BQA	€ -	€ -	€ -	€ -	€ 619	€ -	€ -			
383		D0N0C	€ -	€ -	€ -	€ 4,802	€ -	€ -	€ -			

A	B	C	D	E	F	G	H	I	J	K	L	M
384		D0PRE	€ -	€ -	€ -	€ 15,360	€ -	€ -	€ -			
385		D0SCA	€ -	€ -	€ -	€ -	€ 667	€ -	€ -			
386		D14CC	€ -	€ -	€ -	€ -	€ 1,954	€ -	€ -			
387		D14CD	€ -	€ -	€ -	€ 2,574	€ -	€ -	€ -			
388		D14CG	€ -	€ -	€ -	€ -	€ 24,273	€ -	€ -			
389		D15ZA	€ -	€ -	€ -	€ 286	€ -	€ -	€ -			
390		D1T8A	€ -	€ -	€ -	€ -	€ 937	€ -	€ -			
391		D25KD	€ -	€ -	€ -	€ 43,784	€ 28,390	€ -	€ -			
392		D29JA	€ -	€ -	€ -	€ 191	€ -	€ -	€ -			
393		D2G0A	€ -	€ -	€ -	€ -	€ 5,535	€ -	€ -			
394		D2H1A	€ -	€ -	€ -	€ 2,432	€ -	€ -	€ -			
395		D31QA	€ -	€ -	€ -	€ 156	€ -	€ -	€ -			
396		D33MA	€ -	€ -	€ -	€ 3,469	€ -	€ -	€ -			
397		D33QB	€ -	€ -	€ -	€ 1,909	€ -	€ -	€ -			
398		D37YA	€ -	€ -	€ -	€ -	€ 340	€ -	€ -			
399		D3B5A	€ -	€ -	€ -	€ 5,671	€ -	€ -	€ -			
400		D3L4A	€ -	€ -	€ -	€ -	€ 1,145	€ -	€ -			
401		D797B	€ -	€ -	€ -	€ 540	€ -	€ -	€ -			
402		E510D	€ -	€ -	€ -	€ -	€ 7,761	€ -	€ -			
403		F488A	€ -	€ -	€ -	€ 644	€ -	€ -	€ -			
404		F4SWE	€ -	€ -	€ -	€ -	€ 5,445	€ -	€ -			
405		H248X	€ -	€ -	€ -	€ 18,575	€ -	€ -	€ -			
406		I053A	€ -	€ -	€ -	€ 101	€ -	€ -	€ -			
407		J613A	€ -	€ -	€ -	€ 1,619	€ -	€ -	€ -			
408		M738A	€ -	€ -	€ -	€ -	€ 48,010	€ -	€ -			
409		M738C	€ -	€ -	€ -	€ 5,267	€ -	€ -	€ -			
410		N3TGA	€ -	€ -	€ -	€ -	€ 315	€ -	€ -			
411		P108A	€ -	€ -	€ -	€ 453	€ -	€ -	€ -			
412		S004A	€ -	€ -	€ -	€ -	€ 2,803	€ -	€ -			
413		S3EWE	€ -	€ -	€ -	€ 20,924	€ -	€ -	€ -			
414		S3EWT	€ -	€ -	€ -	€ -	€ 3,909	€ -	€ -			
415		S4MZA	€ -	€ -	€ -	€ -	€ 457	€ -	€ -			
416		T4FWA	€ -	€ -	€ -	€ -	€ 9,545	€ -	€ -			
417		V1JVA	€ -	€ -	€ -	€ 14,687	€ -	€ -	€ -			
418		A910A	€ -	€ -	€ -	€ -	€ -	€ -	€ 106			
419		AK2HA	€ -	€ -	€ -	€ -	€ -	€ -	€ 3,818			
420		AQ7VA	€ -	€ -	€ -	€ -	€ -	€ -	€ 1,342			
421		ATC2	€ -	€ -	€ -	€ -	€ -	€ -	€ 21,333			
422		BGDXA	€ -	€ -	€ -	€ -	€ -	€ -	€ 4,379			
423		BSB7A	€ -	€ -	€ -	€ -	€ -	€ -	€ 3,417			
424		BTL54	€ -	€ -	€ -	€ -	€ -	€ -	€ 4,416			
425		C6T4A	€ -	€ -	€ -	€ -	€ -	€ -	€ 10,659			
426		C71WA	€ -	€ -	€ -	€ -	€ -	€ -	€ 1,154			

A	B	C	D	E	F	G	H	I	J	K	L	M
427		C72GA	€ -	€ -	€ -	€ -	€ 1,943	€ -	€ -			
428		C79MA	€ -	€ -	€ -	€ -	€ -	€ -	€ 8,837			
429		C79MB	€ -	€ -	€ -	€ -	€ -	€ -	€ 714			
430		C7Y2A	€ -	€ -	€ -	€ -	€ -	€ -	€ 19,561			
431		C7Y2C	€ -	€ -	€ -	€ -	€ -	€ -	€ 4,325			
432		C7Z2A	€ -	€ -	€ -	€ -	€ -	€ -	€ 8,690			
433		C83FA	€ -	€ -	€ -	€ -	€ -	€ -	€ 164			
434		C83HE	€ -	€ -	€ -	€ -	€ -	€ -	€ 61,984			
435		C83HF	€ -	€ -	€ -	€ -	€ -	€ -	€ 192			
436		C83TA	€ -	€ -	€ -	€ -	€ -	€ -	€ 28,005			
437		C8H5A	€ -	€ -	€ -	€ -	€ -	€ -	€ 714			
438		D0CYA	€ -	€ -	€ -	€ -	€ -	€ -	€ 1,350			
439		D0D1A	€ -	€ -	€ -	€ -	€ -	€ -	€ 1,564			
440		D0D2A	€ -	€ -	€ -	€ -	€ 1,444	€ -	€ 18,307			
441		D0D2A.	€ -	€ -	€ -	€ -	€ -	€ -	€ 119			
442		D0ENA	€ -	€ -	€ -	€ -	€ -	€ -	€ 25,323			
443		D0NZA	€ -	€ -	€ -	€ -	€ -	€ -	€ 14,433			
444		D0TAA	€ -	€ -	€ -	€ -	€ -	€ -	€ 501			
445		D0XFA	€ -	€ -	€ -	€ -	€ -	€ -	€ 3,310			
446		D11BE	€ -	€ -	€ -	€ -	€ -	€ -	€ 17,866			
447		D1M2A	€ -	€ -	€ -	€ -	€ -	€ -	€ 3,951			
448		D1M2A	€ -	€ -	€ -	€ -	€ -	€ -	€ 64,260			
449		D252A	€ -	€ -	€ -	€ -	€ -	€ -	€ 2,641			
450		D26ZA	€ -	€ -	€ -	€ -	€ -	€ -	€ 476			
451		D2A3A	€ -	€ -	€ -	€ -	€ -	€ -	€ 43,429			
452		D2A3B	€ -	€ -	€ -	€ -	€ -	€ -	€ 114			
453		D38MA	€ -	€ -	€ -	€ -	€ -	€ -	€ 16,233			
454		D38MB	€ -	€ -	€ -	€ -	€ -	€ -	€ 1,927			
455		D3C6C	€ -	€ -	€ -	€ -	€ -	€ -	€ 1,139			
456		D3K7A	€ -	€ -	€ -	€ -	€ -	€ -	€ 562			
457		D3L5A	€ -	€ -	€ -	€ -	€ -	€ -	€ 8,782			
458		E18QA	€ -	€ -	€ -	€ -	€ -	€ -	€ 4,774			
459		H1XPA	€ -	€ -	€ -	€ -	€ -	€ -	€ 91,009			
460		K18BC	€ -	€ -	€ -	€ -	€ -	€ -	€ 9,267			
461		K261A	€ -	€ -	€ -	€ -	€ -	€ -	€ 18,122			
462		K3D6A	€ -	€ -	€ -	€ -	€ -	€ -	€ 8,246			
463		K8N7A	€ -	€ -	€ -	€ -	€ -	€ -	€ 34,114			
464		L0BMA	€ -	€ -	€ -	€ -	€ -	€ -	€ 1,561			
465		L8SFA	€ -	€ -	€ -	€ -	€ -	€ -	€ 591			
466		M1F4A	€ -	€ -	€ -	€ -	€ -	€ -	€ 385			
467		M1F4A	€ -	€ -	€ -	€ -	€ -	€ -	€ 2,897			
468		M1F4B	€ -	€ -	€ -	€ -	€ -	€ -	€ 21,983			
469		P4FPA	€ -	€ -	€ -	€ -	€ -	€ -	€ 1,241			
470		P6U6A	€ -	€ -	€ -	€ -	€ -	€ -	€ 1,936			

A	B	C	D	E	F	G	H	I	J	K	L	M
471		P8TWA	€ -	€ -	€ -	€ -	€ -	€ -	€ 460			
472		P9Z1A	€ -	€ -	€ -	€ -	€ -	€ -	€ 265			
473		R1K8A	€ -	€ -	€ -	€ -	€ -	€ -	€ 17,141			
474		R4F2A	€ -	€ -	€ -	€ -	€ -	€ -	€ 2,961			
475		R76JA	€ -	€ -	€ -	€ -	€ -	€ -	€ 2,138			
476		R8KXA	€ -	€ -	€ -	€ -	€ -	€ -	€ 6,902			
477		R8VLA	€ -	€ -	€ -	€ -	€ -	€ -	€ 163			
478		S0OSCA	€ -	€ -	€ -	€ -	€ -	€ -	€ 5,567			
479		S9E0B	€ -	€ -	€ -	€ -	€ -	€ -	€ 19,974			
480		T53CA	€ -	€ -	€ -	€ -	€ -	€ -	€ 25,568			
481		T53CC	€ -	€ -	€ -	€ -	€ -	€ -	€ 21,341			
482		T5USA	€ -	€ -	€ -	€ -	€ -	€ -	€ 13,110			
483		T655C	€ -	€ -	€ -	€ -	€ -	€ -	€ 11			
484		T655D	€ -	€ -	€ -	€ -	€ -	€ -	€ 413			
485		U9DCA	€ -	€ -	€ -	€ -	€ -	€ -	€ 717			
486		U9DMA	€ -	€ -	€ -	€ -	€ -	€ -	€ 547			
487		V0J2C	€ -	€ -	€ -	€ -	€ -	€ -	€ 1			
488		Subtotals	€ 481,262	€ 2,325,352	€ 144,022	€ 376,849	€ 2,310,141	€ 509,455	€ 853,148			
489		**Annual Empty Freight Cost**	**€ 7,000,229**									
490		**Pool Size Cost Impact**	**€ 993,369**									
491		**Empty Freight & Pool Size**	**€ 7,993,598**									
492												
493		**Safety Stock Cost**	**€ 289,236**									
494		**Total Optimal Cost**	**€ 8,282,835**									
495												
496												

A	B	C	D	E	F	G	H	I	J	K	L	M
497	**Optimal Shipping Template**											
498		**Working Days**	224	214.2	224	209	222	236	213			
499		**Jun-00 through May-01**										
500		**Optimal Container Movements**										
501		***Average per Day***	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA			
502		CZECH	0.00	0.00	0.00	0.00	746.33	0.00	0.00			
503		FRANCE	0.00	895.77	0.00	0.00	1,005.13	0.00	0.00			
504		HUNGARY	0.00	0.00	0.00	0.00	197.01	0.00	0.00			
505		ITALY	0.00	0.00	0.00	0.00	511.00	0.00	0.00			
506		NETHERLANDS	0.00	110.60	0.00	0.00	0.00	0.00	0.00			
507		POLAND	0.00	0.00	0.00	70.39	0.00	0.00	0.00			
508		PORTUGAL	0.00	0.00	0.00	0.00	0.00	0.00	99.92			
509		SLOVAKIA	0.00	0.00	0.00	0.00	8.60	0.00	0.00			
510		SWEDEN	0.00	23.25	0.00	0.00	0.00	0.00	0.00			
511		SWITZERLAND	0.00	0.00	0.00	0.00	15.77	0.00	0.00			
512		BELGIUM	0.00	478.85	0.00	0.00	0.00	0.00	0.00			
513		GERMANY	0.00	0.00	0.00	1,122.97	1,521.23	0.00	0.00			
514		UK	554.16	1,756.89	163.68	0.00	0.00	513.85	0.00			
515		SPANISH	0.00	0.00	0.00	0.00	1.86	0.00	2,596.25			
516		Average per Day	554.16	3,265.35	163.68	1,193.36	4,006.94	513.85	2,696.17			
517		Subtotal	12,393.51									
518												
519												
520	**Average Empty Container Shipping Times**											
521		**Ford Transit Times from Assembly Plant to Component Supplier in Days**										
522		**One Way Data**										
523		Czech Republic	9	5	8	5	5	10	8			
524		France	4	4	5	3	3	4	4			
525		Hungary	5	5	6	5	5	5	8			
526		Italy	4	3	5.5	3	3	4	4			
527		Netherlands	3	1	5.5	1	1	4	3			
528		Poland	8	6	9	6	6	9	8			
529		Portugal	5	5	5	5	5	4	2			
530		Slovakia	9	5	8	5	5	10	8			
531		Sweden	5	6	5	6	6	5.5	6			
532		Switzerland	5	6	6	2	1	5	5			
533		Belgium	2	4	4	1	1	3	3			
534		Germany	3	5.5	5.5	1	1	3	3			
535		United Kingdom	1	1.5	1.5	3	3	0.8	5			
536		Spain	5	5.5	5.5	4	4	6	1			
537												

A	B	C	D	E	F	G	H	I	J	K	L	M
538		**Weighted Shipping**										
539		Czech Republic	0.0000	0.0000	0.0000	0.0000	0.3074	0.0000	0.0000			
540		France	0.0000	0.2848	0.0000	0.0000	0.2484	0.0000	0.0000			
541		Hungary	0.0000	0.0000	0.0000	0.0000	0.0812	0.0000	0.0000			
542		Italy	0.0000	0.0000	0.0000	0.0000	0.1263	0.0000	0.0000			
543		Netherlands	0.0000	0.0088	0.0000	0.0000	0.0000	0.0000	0.0000			
544		Poland	0.0000	0.0000	0.0000	0.0328	0.0000	0.0000	0.0000			
545		Portugal	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0158			
546		Slovakia	0.0000	0.0000	0.0000	0.0000	0.0035	0.0000	0.0000			
547		Sweden	0.0000	0.0111	0.0000	0.0000	0.0000	0.0000	0.0000			
548		Switzerland	0.0000	0.0000	0.0000	0.0000	0.0013	0.0000	0.0000			
549		Belgium	0.0000	0.0011	0.0000	0.0000	0.0000	0.0000	0.0000			
550		Germany	0.0000	0.0000	0.0000	0.0000	0.0670	0.0000	0.0000			
551		United Kingdom	0.0461	0.2095	0.0204	0.0000	0.0000	0.0360	0.0000			
552		Spain	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0036			
553		N2KUA	0.0000	0.0518	0.0000	0.0000	0.0000	0.0000	0.0000			
554		P68PA	0.0000	0.0907	0.0000	0.0000	0.0000	0.0000	0.0000			
555		S3EWF	0.0000	0.0086	0.0000	0.0000	0.0000	0.0000	0.0000			
556		0098A	0.0000	0.0000	0.0000	0.0000	0.0125	0.0000	0.0000			
557		B45XB	0.0000	0.0000	0.0000	0.0000	0.0129	0.0000	0.0000			
558		B45XC	0.0000	0.0000	0.0000	0.0065	0.0000	0.0000	0.0000			
559		B492A	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000			
560		C65ZA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
561		C66LA	0.0000	0.0000	0.0000	0.0008	0.0000	0.0000	0.0000			
562		C7C3A	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000			
563		C7G0A	0.0000	0.0000	0.0000	0.0009	0.0000	0.0000	0.0000			
564		C85HA	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000			
565		C86HA	0.0000	0.0000	0.0000	0.0012	0.0000	0.0000	0.0000			
566		C8L6A	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000			
567		C95YA	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000			
568		C99ZA	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000			
569		C9E5B	0.0000	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000			
570		C9H7A	0.0000	0.0000	0.0000	0.0014	0.0000	0.0000	0.0000			
571		C9J8A	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000			
572		C9N9A	0.0000	0.0000	0.0000	0.0048	0.0000	0.0000	0.0000			
573		CF334	0.0000	0.0000	0.0000	0.0157	0.0000	0.0000	0.0000			
574		D05WA	0.0000	0.0000	0.0000	0.0000	0.0018	0.0000	0.0000			
575		D0BQA	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0000			
576		D0N0C	0.0000	0.0000	0.0000	0.0041	0.0000	0.0000	0.0000			
577		D0PRE	0.0000	0.0000	0.0000	0.0192	0.0000	0.0000	0.0000			
578		D0SCA	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000			
579		D14CC	0.0000	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000			
580		D14CD	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000			

A	B	C	D	E	F	G	H	I	J	K	L	M
581		D14CG	0.0000	0.0000	0.0000	0.0000	0.0029	0.0000	0.0000			
582		D15ZA	0.0000	0.0000	0.0000	0.0002	0.0000	0.0000	0.0000			
583		D1T8A	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000			
584		D25KD	0.0000	0.0000	0.0000	0.0064	0.0038	0.0000	0.0000			
585		D29JA	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000			
586		D2G0A	0.0000	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000			
587		D2H1A	0.0000	0.0000	0.0000	0.0018	0.0000	0.0000	0.0000			
588		D31QA	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000			
589		D33MA	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000	0.0000			
590		D33QB	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000	0.0000			
591		D37YA	0.0000	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000			
592		D3B5A	0.0000	0.0000	0.0000	0.0021	0.0000	0.0000	0.0000			
593		D3L4A	0.0000	0.0000	0.0000	0.0000	0.0007	0.0000	0.0000			
594		D797B	0.0000	0.0000	0.0000	0.0020	0.0000	0.0000	0.0000			
595		E510D	0.0000	0.0000	0.0000	0.0000	0.0016	0.0000	0.0000			
596		F488A	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000			
597		F4SWE	0.0000	0.0000	0.0000	0.0000	0.0016	0.0000	0.0000			
598		H248X	0.0000	0.0000	0.0000	0.0039	0.0000	0.0000	0.0000			
599		I053A	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000	0.0000			
600		J613A	0.0000	0.0000	0.0000	0.0010	0.0000	0.0000	0.0000			
601		M738A	0.0000	0.0000	0.0000	0.0000	0.0074	0.0000	0.0000			
602		M738C	0.0000	0.0000	0.0000	0.0009	0.0000	0.0000	0.0000			
603		N3TGA	0.0000	0.0000	0.0000	0.0000	0.0021	0.0000	0.0000			
604		P108A	0.0000	0.0000	0.0000	0.0006	0.0000	0.0000	0.0000			
605		S004A	0.0000	0.0000	0.0000	0.0000	0.0029	0.0000	0.0000			
606		S3EWE	0.0000	0.0000	0.0000	0.0047	0.0000	0.0000	0.0000			
607		S3EWT	0.0000	0.0000	0.0000	0.0000	0.0005	0.0000	0.0000			
608		S4MZA	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.0000			
609		T4FWA	0.0000	0.0000	0.0000	0.0000	0.0039	0.0000	0.0000			
610		V1JVA	0.0000	0.0000	0.0000	0.0037	0.0000	0.0000	0.0000			
611		A910A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004			
612		AK2HA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0283			
613		AQ7VA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003			
614		ATC2	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0032			
615		BGDXA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0010			
616		BSB7A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009			
617		BTL54	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0013			
618		C6T4A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0023			
619		C71WA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003			
620		C72GA	0.0000	0.0000	0.0000	0.0000	0.0004	0.0000	0.0000			
621		C79MA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0007			
622		C79MB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0053			
623		C7Y2A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0043			

A	B	C	D	E	F	G	H	I	J	K	L	M
624		C7Y2C	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0009			
625		C7Z2A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020			
626		C83FA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020			
627		C83HE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0164			
628		C83HF	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
629		C83TA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0042			
630		C8H5A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0044			
631		D0CYA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0084			
632		D0D1A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0106			
633		D0D2A	0.0000	0.0000	0.0000	0.0000	0.0003	0.0000	0.0018			
634		D0D2A.	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
635		D0ENA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020			
636		D0NZA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0032			
637		D0TAA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0018			
638		D0XFA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008			
639		D11BE	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0043			
640		D1M2A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004			
641		D1M2A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0071			
642		D252A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006			
643		D26ZA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001			
644		D2A3A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0100			
645		D2A3B	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008			
646		D38MA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0035			
647		D38MB	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005			
648		D3C6C	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0002			
649		D3K7A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001			
650		D3L5A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0017			
651		E18QA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0021			
652		H1XPA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0099			
653		K18BC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020			
654		K261A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0036			
655		K3D6A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0018			
656		K8N7A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0031			
657		L0BMA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0105			
658		L8SFA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001			
659		M1F4A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001			
660		M1F4A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0006			
661		M1F4B	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0065			
662		P4FPA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003			
663		P6U6A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0003			
664		P8TWA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001			
665		P9Z1A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0020			
666		R1K8A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0037			
667		R4F2A	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0004			

A	B	C	D	E	F	G	H	I	J	K	L	M
668		R76JA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0005			
669		R8KXA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0017			
670		R8VLA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
671		S0OSCA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0012			
672		S9E0B	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0030			
673		T53CA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0054			
674		T53CC	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0024			
675		T5USA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0030			
676		T655C	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
677		T655D	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001			
678		U9DCA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001			
679		U9DMA	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0008			
680		V0J2C	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000			
681		Subtotals	0.0461	0.6664	0.0204	0.1199	0.8941	0.0360	0.2210			
682		**Average Shipping Days**	**2.0038**									
683												
684												

685 **Pool Size Impact**

686	L - Lead Time in days		2.0038
687	Movements per Day		12,394
688	Annual FLC Container Cost	€	40.00
689	**Pool Size Cost Impact**	**€**	**993,369**
690			
691			

692 **FLC Safety Stock for June 2000 through May 2001**

693	Var X_{IL}	Variance of type 'I' Vehicle Production corresponding to 'L' Location
694	A_{IL}	Containers per type 'I' Vehicle for 'L' Plant
695		

			German	British	Spanish
696			German	British	Spanish
697		**Var X_{IL}**	L=1	L=2	L=3
698	Ka	I=1	0	0	646
699	Fiesta - German	I=2	3,092	0	0
700	Fiesta - British	I=3	0	4,017	0
701	Focus - German	I=4	9,335	0	0
702	Focus - Spanish	I=5	0	0	1,441
703	Mondeo	I=6	22,877	0	0
704	Transit - German	I=7	2,411	0	0
705	Transit - British	I=8	0	1,959	0
706	Escort	I=9	0	259	0
707					
708					

A	B	C	D	E	F	G	H	I	J	K	L	M
709		Average Daily Containers		German	British	Spanish	Other					
710		Model-Supplier Location	A_{IL}	L=1	L=2	L=3	L=4	Subtotals				
711		Ka	I=1	0.16	0.16	0.33	0.27	0.93				
712		Fiesta - German	I=2	0.34	0.37	0.23	0.19	1.12				
713		Fiesta - British	I=3	0.31	0.47	0.19	0.16	1.13				
714		Focus - German	I=4	0.65	0.62	0.36	0.70	2.33				
715		Focus - Spanish	I=5	0.41	0.41	0.84	0.67	2.33				
716		Mondeo	I=6	0.52	0.34	0.30	0.70	1.86				
717		Transit - German	I=7	0.57	0.38	0.34	0.77	2.06				
718		Transit - British	I=8	0.23	0.74	0.34	0.76	2.06				
719		Escort	I=9	0.21	0.40	0.15	0.23	1.00				
720												
721		**L=1**										
722		$A_{IL}^2 * Var X_{IL'}$		L'=2	L'=3							
723		Ka	I=1	0.00	17.39							
724		Fiesta - German	I=2	0.00	0.00							
725		Fiesta - British	I=3	374.33	0.00							
726		Focus - German	I=4	0.00	0.00							
727		Focus - Spanish	I=5	0.00	246.04							
728		Mondeo	I=6	0.00	0.00							
729		Transit - German	I=7	0.00	0.00							
730		Transit - British	I=8	105.16	0.00							
731		Escort	I=9	11.49	0.00							
732		$\sum_I \sum_{L'} (A_{IL}^2 * Var X_{IL'})$		754.41								
733												
734		**L=2**										
735		$A_{IL}^2 * Var X_{IL'}$		L'=1	L'=3							
736		Ka	I=1	0.00	17.10							
737		Fiesta - German	I=2	415.92	0.00							
738		Fiesta - British	I=3	0.00	0.00							
739		Focus - German	I=4	3,587.68	0.00							
740		Focus - Spanish	I=5	0.00	241.84							
741		Mondeo	I=6	2,717.90	0.00							
742		Transit - German	I=7	351.35	0.00							
743		Transit - British	I=8	0.00	0.00							
744		Escort	I=9	0.00	0.00							
745		$\sum_I \sum_{L'} (A_{IL}^2 * Var X_{IL'})$		7,331.78								
746												

L=3

$A_{IL}^2 * Var X_{IL'}$		L'=1	L'=2
Ka	I=1	0.00	0.00
Fiesta - German	I=2	158.47	0.00
Fiesta - British	I=3	0.00	143.69
Focus - German	I=4	1,182.00	0.00
Focus - Spanish	I=5	0.00	0.00
Mondeo	I=6	2,103.56	0.00
Transit - German	I=7	271.93	0.00
Transit - British	I=8	0.00	224.57
Escort	I=9	0.00	6.09
$\sum_I \sum_{L'} (A_{IL}^2 * Var X_{IL'})$		4,090.32	

		German	British	Spanish
$(A_{IL} + A_{I4})^2 * Var X_{IL}$		L=1	L=2	L=3
Ka	I=1	0.00	0.00	232.31
Fiesta - German	I=2	856.02	0.00	0.00
Fiesta - British	I=3	0.00	1,633.25	0.00
Focus - German	I=4	17,205.14	0.00	0.00
Focus - Spanish	I=5	0.00	0.00	3,286.09
Mondeo	I=6	33,862.18	0.00	0.00
Transit - German	I=7	4,377.40	0.00	0.00
Transit - British	I=8	0.00	4,377.64	0.00
Escort	I=9	0.00	103.71	0.00
$\sum_I ((A_{IL} + A_{I4})^2 * Var X_{IL})$		56,300.74	6,114.61	3,518.40

I in region L, L' = L

$$Var\ (L\ inventory) = \sum_I ((A_{IL} + A_{I4})^2 * Var X_{IL}) + \sum_I \sum_{L'} (A_{IL}^2 * Var X_{IL'})$$

Variance of FXC Inventory per 'L' Region

	German	British	Spanish
	L=1	**L=2**	**L=3**
	57,055	**13,446**	**7,609**
Total Variances		**78,110**	

Standard Deviation of FXC Inventory per 'L' Region

German	British	Spanish
L=1	**L=2**	**L=3**
239	**116**	**87**

Periodic Review Regional Safety Stock

z * StDev * (r+L)^0.5

	German	British	Spanish
	L=1	**L=2**	**L=3**
	632	**307**	**231**
Regional Safety Stock	**1,170**		

r = review period, the length of time an order takes to be filled
L = the length of time to ship an order (leadtime)

r	**5**
L	**2.0038**
z	**1.0000**

Safety Stock Cost Impact

FLC/FSC Movements		2,694,654
FLC New	€	200.00
DCP Cost of Capital		10%
Depreciation/Year For New FLC		10%
Cardboard Box	€	22.56
Disposal per Box	€	2.08
Repacking per Box	€	4.48
Forklift and Janitor Impact	€	5.67
Inbound Freight Impact	€	10.38
Cost per Failure	€	45.18
Annual Real Estate Cost per FLC in Safety Stock	€	24.08
Annual Cost of New FLC	€	64.08
z		3.598258
Safety Stock		4,209
Probability of Stock		0.99983979
Probability of No Stock		0.00016021
Stock Out Cost	€	19,505
Safety Stock Cost	€	269,732
Optimal Safety Stock Cost	**€**	**289,236**
Annual Occurrences of no stock		432
Average no stock per Day		2.00

	By Region	Probabilities		
z Value	SS - sigma	F(z)	1-F(z)	% 1-F(z)
1	1,170	0.8413	0.1587	15.87%
2	2,340	0.9772	0.0228	2.28%
3	3,510	0.99865	0.00135	0.13%
4	4,679	0.9999683	0.0000317	0.00317%
4.5	5,264	0.9999966	0.0000034	0.00034%

Competitive Market Prices for Consolidated Transportation. These are not actual Ford costs.

FLC Container Weight		63 Kilograms
Max of Empty FLC per Mega		182 120 x 100 x 40 Cms = 0.48Cbm Total = 182 x 0.40 = 87.36 Cbm
Weight per Mega		11,466 Kilograms
Ford 2002 Exchange Rate		1.6200 £/€
Northern Europe Km rate	€	1.02
Generic Shipping Empty FLC per day	€	1.33

Cost per Mega from Assembly Plant to Country

		Assembly Plants						
Suppliers	***Destination***	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	**Prague**	£ 1,166.00	€ 821.10	£ 1,331.00	€ 695.64	€ 678.30	£ 1,232.00	€ 2,843
France	**Paris**	£ 473.00	€ 391.68	£ 638.00	€ 482.46	€ 390.66	£ 539.00	€ 1,454
Hungary	**Budapest**	£ 1,705.00	€ 1,275.00	£ 1,870.00	€ 1,149.54	€ 1,132.20	£ 1,771.00	€ 2,843
Italy	**Milan**	£ 1,045.00	€ 919.02	£ 1,210.00	€ 811.92	€ 614.04	£ 1,111.00	€ 1,388
Netherlands	**Rotterdam**	£ 385.00	€ 178.50	£ 550.00	€ 249.90	€ 430.44	£ 451.00	€ 1,785
Poland	**Warsaw**	£ 1,540.00	€ 1,248.48	£ 1,705.00	€ 1,134.24	€ 1,298.46	£ 1,606.00	€ 3,173
Portugal		£ 1,595.00	€ 2,137.92	£ 1,760.00	€ 2,240.94	€ 2,129.76	£ 1,661.00	€ 1,040
Slovakia	**Bratislava**	£ 1,540.00	€ 1,094.46	£ 1,705.00	€ 967.98	€ 992.46	£ 1,606.00	€ 2,975
Sweden	**Stockholm**	£ 1,111.00	€ 1,534.50	£ 1,188.00	€ 1,479.50	€ 1,683.00	£ 1,221.00	€ 4,187
Switzerland	**Basle**	£ 803.00	€ 592.62	£ 968.00	€ 485.52	€ 285.60	£ 869.00	€ 1,719
Belgium	**Genk**	£ 385.00	€ 10.20	£ 550.00	€ 112.20	€ 300.90	£ 451.00	€ 1,653
Germany	**Hamburg**	£ 550.00		£ 715.00			£ 616.00	€ 2,314
United Kingdom	**Coventry**							€ 2,975
Spain	**Valencia**	£ 1,320.00	€ 1,741.14	£ 1,485.00	€ 1,700.34	€ 1,535.10	£ 1,386.00	€ 198

Appendix H: Shipping Data

Freight Cost per Empty FLC Container from Assembly Plant to Country

	Assembly Plants						
Suppliers	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	€ 10.38	€ 4.51	€ 11.85	€ 3.82	€ 3.73	€ 10.97	€ 15.62
France	€ 5.54	€ 2.15	€ 5.68	€ 2.65	€ 2.15	€ 4.80	€ 7.99
Hungary	€ 15.18	€ 7.01	€ 16.65	€ 6.32	€ 6.22	€ 15.76	€ 15.62
Italy	€ 9.30	€ 5.05	€ 10.77	€ 4.46	€ 3.37	€ 9.89	€ 7.63
Netherlands	€ 6.09	€ 0.98	€ 4.90	€ 1.37	€ 2.37	€ 4.01	€ 9.81
Poland	€ 13.71	€ 6.86	€ 15.18	€ 6.23	€ 7.13	€ 14.30	€ 17.44
Portugal	€ 14.20	€ 11.75	€ 15.67	€ 12.31	€ 11.70	€ 14.78	€ 5.72
Slovakia	€ 13.71	€ 6.01	€ 15.18	€ 5.32	€ 5.45	€ 14.30	€ 16.35
Sweden	€ 9.89	€ 8.43	€ 10.57	€ 8.13	€ 9.25	€ 10.87	€ 23.00
Switzerland	€ 7.15	€ 3.26	€ 8.62	€ 2.67	€ 1.57	€ 7.74	€ 9.44
Belgium	€ 4.76	€ 0.12	€ 4.90	€ 0.56	€ 1.67	€ 4.01	€ 9.08
Germany	€ 4.90	€ 2.36	€ 6.36	€ 1.86	€ 1.43	€ 5.48	€ 12.71
United Kingdom	€ 3.88	€ 4.87	€ 3.93	€ 5.32	€ 6.43	€ 4.20	€ 16.35
Spain	€ 11.75	€ 9.57	€ 13.22	€ 9.34	€ 8.43	€ 12.34	€ 0.81

Transit Times In Days

	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA
Czech Republic	9	5	8	5	5	10	8
France	4	4	5	3	3	4	4
Hungary	5	5	6	5	5	5	8
Italy	4	3	5.5	3	3	4	4
Netherlands	3	1	5.5	1	1	4	3
Poland	8	6	9	6	6	9	8
Portugal	5	5	5	5	5	4	2
Slovakia	9	5	8	5	5	10	8
Sweden	5	6	5	6	6	5.5	6
Switzerland	5	6	6	2	1	5	5
Belgium	2	4	4	1	1	3	3
Germany	3	5.5	5.5	1	1	3	3
United Kingdom	1	1.5	1.5	3	3	0.8	5
Spain	5	5.5	5.5	4	4	6	1

Background Data

Ford Demand Jun-00 through May-01

Average per Day	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA	Subtotals
CZECH	14.18	178.30	0.00	44.22	309.81	27.64	186.75	760.91
FRANCE	17.48	624.83	24.62	40.01	678.88	126.35	388.94	1,901.11
HUNGARY	4.02	103.78	1.08	8.66	54.44	2.44	27.67	202.10
ITALY	39.39	184.80	10.13	97.87	103.16	23.84	64.74	523.93
NETHERLANDS	0.07	67.41	0.03	0.00	23.44	5.28	13.06	109.28
POLAND	0.00	21.17	0.00	0.00	2.05	0.99	44.55	68.76
PORTUGAL	4.57	21.69	1.84	9.85	22.09	2.10	36.36	98.50
SLOVAKIA	0.00	5.15	0.00	0.00	2.49	0.00	1.20	8.84
SWEDEN	0.00	0.00	0.00	0.00	14.16	0.00	8.62	22.78
SWITZERLAND	0.00	16.21	0.00	0.00	0.14	0.00	0.00	16.34
BELGIUM	0.46	61.47	34.58	2.29	326.09	0.00	40.70	465.61
GERMANY	148.97	845.89	0.00	358.06	794.56	57.65	436.84	2,641.96
UK	232.42	603.64	66.22	391.02	1,064.58	183.32	473.44	3,014.63
SPANISH	92.58	531.05	25.18	241.36	611.05	84.25	973.31	2,558.80
Subtotals	554.16	3,265.38	163.68	1,193.36	4,006.94	513.85	2,696.17	
Average per Day for Europe	12,393.54							12,393.54

Vehicle Production		Mondeo					Focus
	Fiesta	Transit	Escort	Fiesta	Focus	Transit	Ka
	109,652	265,414	36,796	222,822	381,231	58,728	189,440
		99,026					142,805
Subtotal		*364,440*					*332,245*
Total Vehicles 6/00 - 5/01	1,505,914						
Containers Per Vehicle							
	1.1320	1.8892	0.9419	1.1193	2.3333	2.0590	2.3333
		2.0590					0.9261
Working Days		212					213
		220					213
	224	214.2	224	209	222	236	213

Appendix I: Background Data

Ford Demand Jun-00 through May-01

Annual Movements	DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA	Subtotals
CZECH	3,177	38,187	0	9,243	68,778	6,523	39,777	165,685
FRANCE	3,916	133,821	5,514	8,363	150,711	29,819	82,844	414,988
HUNGARY	900	22,227	243	1,810	12,086	576	5,894	43,736
ITALY	8,824	39,579	2,268	20,455	22,902	5,626	13,789	113,443
NETHERLANDS	16	14,436	6	0	5,203	1,245	2,782	23,688
POLAND	1	4,534	0	0	454	234	9,489	14,712
PORTUGAL	1,024	4,645	413	2,058	4,904	495	7,745	21,284
SLOVAKIA	0	1,102	0	0	553	0	255	1,910
SWEDEN	0	0	0	0	3,144	0	1,835	4,979
SWITZERLAND	0	3,471	0	0	30	0	0	3,501
BELGIUM	104	13,164	7,747	479	72,393	0	8,670	102,557
GERMANY	33,369	181,167	0	74,835	176,392	13,605	93,046	572,414
UK	52,061	129,283	14,833	81,724	236,336	43,263	100,843	658,343
SPANISH	20,739	113,737	5,641	50,445	135,654	19,882	207,316	553,414
Subtotals	124,131	699,353	36,665	249,412	889,540	121,268	574,285	
Total Movements for Europe	2,694,654							2,694,654

Average Daily Containers		German	British	Spanish	Other	
Model-Supplier Location	A_{IL}	L=1	L=2	L=3	L=4	Subtotals
Ka	I=1	0.16	0.16	0.33	0.27	0.93
Fiesta - German	I=2	0.34	0.37	0.23	0.19	1.12
Fiesta - British	I=3	0.31	0.47	0.19	0.16	1.13
Focus - German	I=4	0.65	0.62	0.36	0.70	2.33
Focus - Spanish	I=5	0.41	0.41	0.84	0.67	2.33
Mondeo	I=6	0.52	0.34	0.30	0.70	1.86
Transit - German	I=7	0.57	0.38	0.34	0.77	2.06
Transit - British	I=8	0.23	0.74	0.34	0.76	2.06
Escort	I=9	0.21	0.40	0.15	0.23	1.00

June 2000 - May 2001
Spanish Suppliers
FLC/FSC Container Movements

Ford Code		DAGENHAM	GENK	HALEWOOD	KOELN	SAARLOUIS	SOTON	VALENCIA	Genk Km	Cologne Km	Saarlouis Km	Valencia Km
A910A	SPAIN	0	0	0	0	0	0	1,064	1760	1720	1559	20
AK2HA	SPAIN	0	0	0	0	0	0	76,389	1707	1667	1506	10
AQ7VA	SPAIN	161	0	0	380	0	3	239	1463	1551	1454	343
ATC2	SPAIN	0	1,997	0	0	4,373	0	2,184	1467	1556	1458	499
BGDXA	SPAIN	0	0	0	0	0	0	2,577	1681	1770	1673	340
BSB7A	SPAIN	0	0	0	0	1,554	0	812	1459	1548	1451	289
BTL54	SPAIN	0	21	0	0	3,449	0	50	1465	1425	1263	251
C6T4A	SPAIN	0	5,669	0	0	0	549	0	1463	1551	1454	343
C71WA	SPAIN	0	0	202	477	0	0	0	1681	1770	1673	340
C72GA	SPAIN	0	237	0	0	0	0	0	1261	1350	1253	781
C79MA	SPAIN	0	0	0	0	1,760	0	109	2010	2099	2002	946
C79MB	SPAIN	2,332	0	11	4,952	6,994	1	0	1751	1710	1549	10
C7Y2A	SPAIN	776	8,625	0	2,317	0	0	0	1375	1335	1174	334
C7Y2C	SPAIN	0	1,746	0	0	0	799	0	1681	1770	1673	340
C7Z2A	SPAIN	0	5,013	304	0	0	0	0	1375	1335	1174	327
C83FA	SPAIN	1,206	975	0	2,893	0	0	394	1727	1687	1526	6
C83HE	SPAIN	0	1,211	0	0	27,769	0	15,155	1426	1386	1225	281
C83HF	SPAIN	0	3	0	0	73	0	29	1696	1785	1688	365
C83TA	SPAIN	0	0	1,733	0	0	0	9,496	2046	2135	2038	499
C8H5A	SPAIN	0	5,105	0	0	0	2,113	4,682	1751	1711	1550	12
D0CYA	SPAIN	0	598	0	0	12,583	0	9,323	1751	1711	1550	12
D0D1A	SPAIN	3,040	10,098	581	7,524	98	25	7,083	1743	1703	1542	11
D0D2A	SPAIN	474	1,514	0	960	0	0	2,010	1262	1351	1254	766
D0D2A.	SPAIN	1	8	0	4	9	0	10	1283	1371	1274	742
D0ENA	SPAIN	0	2,517	0	2	562	1,528	747	2010	2099	2002	946
D0NZA	SPAIN	0	0	0	0	5,699	0	2,845	1376	1336	1174	338
D0TAA	SPAIN	729	1,670	78	1,507	273	4	515	1738	1698	1537	21
D0XFA	SPAIN	0	2,054	9	0	0	0	0	1390	1350	1189	321
D11BE	SPAIN	724	4,158	266	1,501	2,896	0	2,137	1453	1413	1252	306
D1M2A	SPAIN	169	262	14	562	0	0	173	1424	1512	1415	670
D1M2A	SPAIN	2,126	7,698	281	5,962	0	140	2,983	1424	1512	1415	670
D252A	SPAIN	0	619	0	0	2	145	788	1681	1770	1673	340
D26ZA	SPAIN	0	3	0	0	0	0	266	1705	1793	1693	354
D2A3A	SPAIN	0	9,225	0	0	4,024	4,768	9,053	1401	1361	1199	321
D2A3B	SPAIN	0	0	0	0	2,272	0	0	1707	1667	1506	10
D38MA	SPAIN	1,350	114	225	2,553	0	62	5,221	1376	1363	1162	341
D38MB	SPAIN	300	0	0	1,048	0	0	0	1423	1383	1221	286

D3C6C	SPAIN	0	0	0	0	0	0	644	1705	1793	1693	354
D3K7A	SPAIN	0	0	0	0	0	0	356	1716	1805	1708	316
D3L5A	SPAIN	0	2,497	0	102	1,871	0	1	1358	1515	1353	393
E18QA	SPAIN	1,665	0	0	4,114	0	0	10	1547	1507	1345	165
H1XPA	SPAIN	0	5,839	0	2,358	9,353	2,735	6,454	1286	1375	1278	681
K18BC	SPAIN	0	4,950	0	0	0	0	456	1463	1551	1454	343
K261A	SPAIN	1,289	0	265	2,332	5,856	24	34	1425	1385	1224	370
K3D6A	SPAIN	603	1,644	0	651	0	0	2,042	1375	1335	1174	334
K8N7A	SPAIN	2,654	144	559	3,429	0	0	1,538	1575	1664	1567	820
L0BMA	SPAIN	704	45	0	1,142	17,850	0	8,645	1751	1710	1549	11
L8SFA	SPAIN	0	0	0	0	0	0	332	1368	1329	1167	356
M1F4A	SPAIN	0	0	0	0	125	0	103	1376	1336	1174	338
M1F4A	SPAIN	0	0	10	0	1,016	0	689	1376	1336	1174	338
M1F4B	SPAIN	0	5	0	0	10,455	2	7,062	1465	1425	1263	251
P4FPA	SPAIN	0	801	0	0	4	0	1	1399	1359	1197	308
P6U6A	SPAIN	10	0	0	797	0	0	0	1321	1409	1320	480
P8TWA	SPAIN	1	214	0	0	0	76	0	1363	1323	1162	316
P9Z1A	SPAIN	0	14	0	0	0	0	5,293	1707	1667	1506	10
R1K8A	SPAIN	0	7,014	0	0	0	2,904	81	1374	1334	1172	343
R4F2A	SPAIN	326	0	0	698	0	1	0	1447	1536	1439	578
R76JA	SPAIN	0	0	0	0	0	0	1,354	1716	1805	1708	316
R8KXA	SPAIN	0	3,007	0	1	0	1,520	0	1401	1364	1202	305
R8VLA	SPAIN	0	71	0	0	0	25	0	1681	1770	1673	340
S0OSCA	SPAIN	0	0	0	0	0	0	3,129	1683	1772	1675	356
S9E0B	SPAIN	5	6,942	1,062	0	0	0	0	1467	1556	1458	499
T53CA	SPAIN	84	1,283	0	0	9,896	0	3,395	1365	1325	1163	349
T53CC	SPAIN	0	6,354	0	0	0	0	0	1282	1370	1273	672
T5USA	SPAIN	0	4,034	0	0	1,175	2,447	490	1375	1335	1174	322
T655C	SPAIN	0	0	0	0	0	0	7	1375	1335	1174	322
T655D	SPAIN	0	0	0	0	0	0	241	1463	1551	1454	343
U9DCA	SPAIN	0	185	0	1	0	11	0	1293	1382	1285	728
U9DMA	SPAIN	10	0	0	2,201	0	0	21	1556	1639	1477	49
V0J2C	SPAIN	0	0	0	0	0	0	22	1707	1667	1506	10
		20,739	116,183	5,600	50,468	131,991	19,882	198,734				
		543,597										

June 2000 - May 2001
Belgium & German Suppliers
FLC/FSC Container Movements

Supplier Code	Country Name	Sup to Dag	Sup to Genk	Sup to Halewood	Sup to Koeln	Sup to Saarlouis	Sup to Soton	Sup to Valencia	Subtotals	Km to Genk	Km to Cologne	Km to Saarlouis
N2KUA	BELGIUM		7,928	54	175	18,032		8,719	34,908	10	110	295
P68PA	BELGIUM		691			60,055		385	61,131	30	148	339
S3EWF	BELGIUM		3,111			1,789		874	5,774	53	166	272
0098A	GERMANY	3,490	1,848	902	6,720	11,769		8,880	33,609	303	290	5
B45XB	GERMANY	1,074	25,862	125	2,397	2,415	2,007	981	34,861	785	661	606
B45XC	GERMANY	1,758	12,354	1	3,420	38			17,571	597	473	513
B492A	GERMANY	205	232	106	457		1	287	1,288	134	20	246
C65ZA	GERMANY	19			38				57	142	32	226
C66LA	GERMANY	340	259		2	1,625	2	24	2,252	559	440	740
C7C3A	GERMANY			163					163	121	13	314
C7G0A	GERMANY				34			2,339	2,373	155	49	356
C85HA	GERMANY				595				595	155	49	356
C86HA	GERMANY		617			1,761		870	3,248	379	267	494
C8L6A	GERMANY		819						819	552	456	376
C95YA	GERMANY	1	384	66					451	257	145	452
C99ZA	GERMANY				144		154		298	369	246	285
C9E5B	GERMANY		1,916						1,916	345	222	190
C9H7A	GERMANY		3,862						3,862	205	78	374
C9J8A	GERMANY	69	98	2		8	100		277	205	78	374
C9N9A	GERMANY				2	8,407	8	4,393	12,810	180	53	376
CF334	GERMANY	5,223	24,595		12,458	27			42,303	455	328	439
D05WA	GERMANY	103	2,886	1	270	1,031		590	4,881	767	625	588
D0BQA	GERMANY		191		11	321		185	708	319	516	156
D0N0C	GERMANY		17		3	7,866		3,241	11,127	204	77	266
D0PRE	GERMANY	10	19,099	485		20,044	2,111	9,962	51,711	158	53	360
D0SCA	GERMANY				366		19		385	492	368	309
D14CC	GERMANY							673	673	621	498	518
D14CD	GERMANY	286	1,445		48	1			1,780	377	258	566
D14CG	GERMANY	2,565	12		5,230	25			7,832	693	569	553
D15ZA	GERMANY				0			655	655	205	78	374
D1T8A	GERMANY		295						295	746	622	567
D25KD	GERMANY	4,696	6,077		10,900	96	2,662	3,268	27,699	574	450	490
D29JA	GERMANY	166	396		409	265		128	1,364	150	25	283

D2G0A	GERMANY	1,033			1,656		2		2,691	543	437	367
D2H1A	GERMANY	29	4,793						4,822	216	90	386
D31QA	GERMANY	22	1,743		96				1,861	544	15	299
D33MA	GERMANY		36			1,802		901	2,739	342	226	268
D33QB	GERMANY	705			1,185		1	1	1,892	292	180	488
D37YA	GERMANY					1,555			1,555	278	268	39
D3B5A	GERMANY		5,396		26	200			5,622	292	180	488
D3L4A	GERMANY	50			84	1,237		632	2,003	321	224	102
D797B	GERMANY	385	89			3,596	47	1,231	5,348	130	18	293
E510D	GERMANY	6	2,593			1,546		265	4,410	491	386	314
F488A	GERMANY		335						335	467	343	383
F4SWE	GERMANY		3,254		5		984		4,243	356	232	229
H248X	GERMANY	2,603	2	1,042	5,243		2	1,498	10,390	431	319	480
I053A	GERMANY	382			981		28		1,391	121	13	314
J613A	GERMANY	702			1,892		9		2,603	210	111	418
M738A	GERMANY	568	5,264	168	921	7,636		5,273	19,830	583	460	432
M738C	GERMANY	1			496	1,296		505	2,298	529	409	683
N3TGA	GERMANY					4,337		1,291	5,628	285	275	10
P108A	GERMANY				4	1,170		475	1,649	163	49	357
S004A	GERMANY	395	762		731	4,668		1,383	7,939	243	233	63
S3EWE	GERMANY		2,605	2		6,518		3,488	12,613	422	296	407
S3EWT	GERMANY	1	1,383	1			50		1,435	662	558	486
S4MZA	GERMANY		188						188	518	394	434
T4FWA	GERMANY	89	2,498	51	369	5,017	2	2,487	10,513	339	225	162
V1JVA	GERMANY		342			6,595	192	2,760	9,889	377	265	356
	Subtotals	26,976	146,277	3,169	57,368	182,748	8,381	68,644	493,563			