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May 10, 2000

Mr. James Kinney, Indirect Supplier Program Leader
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Dear Mr. Kinney:

Enclosed is our report entitled *The Reduction of Inbound Air Transportation Costs at Caribe General Electric*. It was written at Caribe GE during the period of March 20 through May 10, 2000. Preliminary work was completed in Worcester, Massachusetts, prior to our arrival in Puerto Rico. Copies of this report are simultaneously being submitted to Professors Menides and Woods for evaluation. Upon faculty review, the original copy of this report will be catalogued in the Gordon Library at Worcester Polytechnic Institute. We appreciate the time which you, Mr. Robert Chesser, and all the employees in your offices have devoted to us.

Sincerely,

Sergio Deana
Sergio Deana

Andrew D. Merrill
Andrew Merrill

Hilary Seling
Hilary Seling

Report Submitted to:

Professor Douglas Woods and Professor Laura Menides

Puerto Rico, Project Center

By

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In Cooperation With

James Kinney, Indirect Supplier Program Leader

Caribe General Electric, Industrial Systems

THE REDUCTION OF INBOUND AIR TRANSPORTATION COSTS AT CARIBE GENERAL ELECTRIC

May 10, 2000

This project report is submitted in partial fulfillment of the degree requirements of Worcester Polytechnic Institute. The views and opinions expressed herein are those of the authors and do not necessarily reflect the positions or opinions of Caribe General Electric or Worcester Polytechnic Institute.

This report is the product of an education program, and is intended to serve as partial documentation for the evaluation of academic achievement. The report should not be construed as a working document by the reader.

ABSTRACT

The goal of this IQP was to reduce the inbound transportation costs at Caribe General Electric's ten manufacturing plants in Puerto Rico by forty percent. To accomplish this goal, we observed air transportation routines at the plants and conducted interviews at the four plants that spent the most on air transportation. We then created recommendations based on the problems observed at these plants. In addition we addressed the societal impacts of our recommendations in the form of resistance to change.

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EXECUTIVE SUMMARY

This project was completed in conjunction with the Caribe General Electric Sourcing Office located in Bayamon, Puerto Rico. The objective of the project was to decrease the inbound air transportation costs of the Caribe GE plants by 40 percent. Preliminary research was conducted at Worcester Polytechnic Institute. Topics relating to inventory management, various transportation methods, and inventory tracking were investigated. Past spending data was also obtained and analyzed in order to determine the extent of air transportation usage at the various manufacturing plants on the island.

In order to gain a better understanding of the procedures being followed at specific plants, we traveled to these plants and interviewed various personnel. These personnel included the Materials Manager and Materials Planners. Our main focus during these interviews was on the inventory tracking procedures at each plant, as well as the safety stock quantities, re-order quantities and current procedures being followed for authorizing air shipments. Best practice methods were then determined by comparing the operations of the manufacturing plants that were visited.

Two major conclusions were drawn from our best practice methods. The first was that a control system needed to be implemented that would keep track of all requestors at each plant and their premium air usage on a weekly basis. This system would be used as a diagnostic tool for determining the cause of high transportation costs. It would also provide a preventative measure by correcting any problems before air transportation costs became excessive.

Secondly, we proved that it was often more cost effective to keep infrequently used parts in inventory than it was to expedite them using next-day or second-day air services. This conclusion was reached by calculating the cost of holding materials in inventory for several different time periods, and comparing these costs to the cost associated with expedited air shipping, including the cost of inventory carrying while the materials are in transit. A graph was then generated to clearly depict how long materials would need to be held in stock in order for air shipment, including inventory in transit costs, to become cheaper than inventory carrying costs.

From our plant visits we determined that issues such as default weight limits for air authorizations, problems with suppliers under consignment, poor inventory management, and misuse of safety stocks all contribute to the high usage of air transportation. Correcting these matters will assist in lowering the air transportation costs at the Puerto Rican GE plants.

It will be important to account for resistance to change that could result from our recommendations. Planners in the past have only considered inventory-carrying costs and inventory sizes when ordering materials. As a result of our recommendations, they will now have to take into account transportation costs as well, and the minimization of total cost. It will be the job of the Materials Manager to show the importance of minimizing both transportation and inventory carrying costs.

Chapter 1 **INTRODUCTION**

Caribe GE* is a branch of General Electric Industrial systems consisting of ten manufacturing plants located on the island of Puerto Rico. These ten facilities produce goods ranging from residential and industrial circuit breakers to control systems. A more detailed summary of these plants' products can be found in Appendix A. The majority of Caribe GE's suppliers are located in the contiguous United States and are shipping raw materials to Puerto Rico via air and ocean routes. Caribe GE's ten plants in Puerto Rico incurred excessively high air transportation costs in 1999. According to our liaison, James Kinney, these air shipments were due to the untimely fashion in which orders for raw materials were placed. This inefficiency necessitated a large number of overnight air shipments, which were extremely costly to GE. The goal of this project was to reduce these costs by 40 percent by shipping raw materials via the established ocean route and reducing the use of air transportation. In order to achieve this goal, it was necessary to determine the causes of GE's excessive use of air transportation by examining their current system for ordering and tracking raw materials. After examining the practices and procedures of several manufacturing plants, we proposed a proactive control structure to eliminate inefficiencies and reduce transportation costs.

The analysis of GE's manufacturing processes focused on the methods of inventory management being employed and the procedures for procurement of raw materials. In order to improve upon the current processes, a system that enforces proper tracking of inventory and reduces the use of next day shipping was proposed.

This report was prepared by members of Worcester Polytechnic Institute Puerto Rico Project Center. The relationship of the Center to Caribe General Electric and the relevance of the topic to Caribe General Electric are presented in Appendix A.

By increasing the accuracy and efficiency of the inventory tracking methods of each plant, material lead times will be increased and suppliers will be given sufficient time to send materials via ocean transport.

When the project was initialized, each of the ten General Electric plants in Puerto Rico were maintaining their own individual inventory tracking systems. Consequently, an analysis of each individual plant was necessary in order to develop procedures to reduce air transportation costs. The first goal was to determine which of the ten plants were spending the most on air transportation. Once this was established, an examination of their inventory tracking and management systems was conducted. A comparison was then performed on the methods employed by plants with a low number of air shipments to those plants with frequent usage of air. The objective was to establish a procedure that could be implemented at all ten plants to reduce the overall usage and associated cost of air transportation.

In addition to the inventory management process, methods of transportation from the suppliers in the mainland United States to General Electric's plants in Puerto Rico were studied. The drivers of transportation costs for these raw materials were examined, and a list of suppliers most frequently shipping materials via air was compiled. The causes for these frequent air shipments were determined, and control measures to reduce these costs were developed.

The project was assigned as an Interactive Qualifying Project (IQP). The objective of the IQP is to examine the ways in which science and technology interact with societal structures and values. To fulfill the requirements of an IQP, the project encompassed both technological and societal aspects. The technological side of the

IQP dealt with the analysis of methods for transporting raw materials to GE's plants in Puerto Rico and the ways in which the cost of this transportation could be reduced. In order to meet the societal requirements of the IQP, human resource aspects were focused on. These aspects involved the reactions of employees to the interview process we carried out along with any changes proposed by our recommendations. In preparing for interviews at the manufacturing plants, anticipated employee reactions were taken into consideration. The interviewing methods employed were carefully selected so as to gain as much information as possible without having employees be deterred by our presence. In determining which processes were responsible for the high transportation costs, we interacted with several plant personnel, some of whom were bothered by our investigation of their plants. Other personnel did not consider the responsibility of keeping transportation costs down to be a significant part of their jobs and thus had to be encouraged to do so by the presentation of facts. These are just a few of the human resources issues that had to be dealt with in order to fully implement an improved system for reducing GE's transportation costs.

The issue of transportation costs is not only important to GE but also to other manufacturing companies in Puerto Rico. Due to the fact that Puerto Rico is an island, it is in a unique situation with regard to the procurement of raw materials. In most cases, materials for manufacturing must be brought in from the United States or from other countries around the world. Thus, the mode of transportation for raw materials is a constant concern. Several possible methods for transporting raw materials exist. When determining which method will best meet the needs of the company, the costs associated with each method must be weighed against the amount of time a material is in transit. The solutions proposed to General Electric for reducing their transportation costs could also be of use to other manufacturing companies that are located on the island.

We will address both the technological and societal aspects of this project in order to successfully fulfill the goals of General Electric and of the Interactive Qualifying Project (IQP), a degree requirement of Worcester Polytechnic Institute.

Chapter 2 **LITERATURE REVIEW**

Introduction

This section of the project is intended to provide an overview of the background information necessary to understanding our project. Included is information about supply chain management, inventory-tracking methods, methods of raw materials transport and the associated costs, factors influencing costs of transportation, and manufacturing efficiency. Several factors influence materials, inventory, shipping and carrying costs. Some of these include the accuracy of inventory tracking, packaging costs, and actual shipping costs. In our effort to reduce the costs of shipping raw materials from suppliers in the United States to manufacturing plants in Puerto Rico, we were required to analyze these factors as well as determine which factors were causing the high frequency of air shipments at each plant.

In addition to these topics, we covered background information regarding resistance to change, management of change, and other possible human resource aspects that pertain to our project. Human reactions to the implementation of new ideas and new systems were focused upon.

Supply Chain Management

As its name implies, supply chain management deals with managing the supply chain, which is a virtual map of the entire production process from raw materials acquisition to product distribution (Gooley 1998). Beamon (1999) tells us that a supply chain is a one-way path that involves a company procuring raw materials, converting them into finished goods, and distributing the finished product to the customer. He states that it is critical that the supply chain is managed properly in order to maximize efficiency during the production process. This topic is further developed in the following sections.

According to many authors, a company must employ some form of inventory-tracking methods to procure raw materials in a timely, and cost effective manner. These methods are intended to allow a company to keep track of past demand and employ forecasting methods to predict the quantities of a particular raw material that will be needed in the future. Inventory tracking also warns the company when material stock is low, so that raw materials can be ordered ahead of time and transported in the most cost-effective and timely manner.

The factors influencing the cost of transportation must be studied, because the costs that the company incurs due to transportation are passed on to the customer. Transportation costs account for a large portion of the overall production cost. In order for the company to remain competitive it must reduce total costs, including those incurred with materials transport, as much as possible.

Chase (1998) notes that costs associated with transportation account for a large portion of the finished product price. He asserts that if manufacturing efficiency can be increased while transportation costs are reduced, the finished product can be sold to the customer at a considerably lower cost. Chase (1998) also states that if the company can lower the cost to consumers, they will become a more powerful competitor in their respective market.

Supply Chain Management Branches

There are several different branches within supply chain management. The two branches that are pertinent to our topic are logistics management and purchasing management.

Logistics Management

Goh (1998) describes logistics management as the process of planning and applying methods that create an efficient and inexpensive way to transport and store both raw materials and finished goods within the supply chain in order to effectively meet consumer demands. According to several authors, logistics management can provide a large competitive advantage to a company if cost can be controlled and service can be improved.

Purchasing Management

The second branch of supply chain management to be discussed is purchasing management. According to our liaison one of the major contributors to excessive transportation costs within the Puerto Rico plants, is the inefficiency of the materials purchasing departments. The following background information was intended to aid us in eliminating this inefficiency. Fung (1999) states that when performing their tasks, purchasing managers need to focus on two things. First, they need to respond to the needs of production managers within the company. Fung (1999) also refers to these production managers as "internal customers." Secondly, he says, purchasing managers need to make the purchasing of raw materials profitable for both the supplier and the company procuring these raw materials.

Supply Chain Process

Quinn (1998) says that supply chain management spans multiple departments in addition to the logistics department. He asserts that the supply side of the chain deals with purchasing raw materials, which begins with the purchasing department. In turn, the purchasing department is connected to suppliers from whom the company receives its raw materials. These suppliers are connected to other suppliers who provide them with raw materials. Beamon (1999) maps out the above process, which functions as the supply chain. In order to ensure that a company's supply chain operates both efficiently and effectively, supply chain management is employed. Cox (1999) says that supply chain management is also responsible for creating methods and techniques that improve a supply chain's efficiency.

According to Beamon (1999) and Quinn (1998), the two main objectives of supply chain management are to reduce risk and uncertainty in the supply chain and to optimize its efficiency by weighing all factors influencing it. They also postulate that if both risk and uncertainty are reduced, inventory levels, cycle times, and customer service will all be improved. Quinn (1998) stated that one of the most effective methods of supply chain management is focusing on customer demand. He then said that when customer demand is targeted as the primary focus, extraneous waste in the form of unneeded raw materials is reduced.

Supply Chain Management Instruments

There are specific tools that supply chain managers utilize in order to accomplish the two main objectives stated above. In his textbook, Chase (1998) lists these instruments as forecasting, aggregate planning, inventory planning and scheduling. In addition he states that all of these are linked to a supply chain database and follow a specified order. Forecasting is the initial stage of the cycle. This is where future demand is calculated. The information obtained from the forecast is used to create the aggregate plan. The aggregate plan is the production schedule based on future demand. In the case of General Electric in Puerto Rico, the aggregate plan, which is also known as the Production Scheduling Information (PSI), forecasts demand for a year and is based primarily on demand from the previous year. Once the aggregate plan is finished, it is then used to create an inventory plan. The inventory plan schedules what will be kept in the inventory over the period of time that the aggregate plan covers. Chase (1998) affirms that all of these tools are linked to the supply chain database, to facilitate efficient access to the information.

Outsourcing

One of the methods used by companies to create a more efficient and profitable supply chain is the principle of outsourcing (Chase 1998; Doyle 1999). Several authors confirm that in the past ten years many companies have begun using the outsourcing technique. One of the major reasons for this was the deregulation of transportation. In addition to this, the use of outsourcing has increased due to companies placing an increased focus on the part of the supply chain they perform best, reduction in inventories, and improvements in logistics management computer programs (Chase 1998; Dobrin 1999).

Outsourcing occurs when a firm pays for an outside company to provide materials or services that were once taken care of within the structure of the original company (Chase, 1998). In order to further illustrate this principle, Chase, et al (1998) provides an example. Company A used to make its own ball bearings which were then used in Company A's own manufacturing process. After some analysis, Company A found it more profitable to purchase the ball bearings from Company B, instead of making them internally. Chase, et al (1998) claims that outsourcing is very helpful to a company because it allows the company's primary focus to lie on the aspects of the supply chain in which the company excels.

Several authors agree that supply chain management is critical if companies wish to optimize their supply chain. There are many tools available to supply chain managers for accomplishing this goal. These tools range from theories and methods to complex computer models. Supply chain managers are essential in order for a business to operate efficiently and maximize profit.

Distribution

Barnes (1997) describes the fundamental goal of supply chain management as the reduction of costs with a simultaneous increase in customer satisfaction. He states that there are many aspects influencing both of these outcomes. He also states that from a distributor's point of view, these factors include the location of distribution centers; the total number of such distribution centers; the volume of stock located in each center; which customers should be serviced from which centers; how the orders should be handled going into and out of the center; and what transportation methods should be utilized in shipping the inventory. According to Barnes, being able to balance these factors and create the best possible solution, requires a fairly detailed analysis, known as distribution network planning.

Packaging

Richardson (1999) states that another determiner of shipping costs is the way in which materials are packaged. For convenience, standardized sizes of boxes are typically employed, though a custom fit can often increase the strength of packaging, as well as reduce bulk. He declares that in a tighter fitting package, containers can easily be stacked with little concern for the possibility of crushing. Depending upon the type of materials being shipped, there are specifications for the weight and strength of their packaging. Richardson also attests that when using the standardized shipping containers, typically cardboard boxes, over design is often present. If containers can be designed with a specific product in mind, cost can be reduced.

According to Richardson (1999), another cost that may not be immediately obvious is the cost incurred with the disposal of waste or recyclable materials. An example of this, which he provides, is protective padding, which adds to both package weight and disposal costs, and can account for a large amount of extra expenditure. Switching to returnable packaging methods can serve to reduce the amount of money spent on shipping. There are several collapsible, reusable and recyclable shipping containers on the market, which may serve as a viable option to the current methods (Richardson, 1999). This change could not only reduce cost to the shipper, but also cut down on unnecessary accumulated waste from packaging materials.

Inventory Tracking

An inventory is a stock of materials that will be used in future production. According to Noon (http://northstar.bus.utk.edu/mgt301/slides/ch10.html), there are two important reasons to carry an inventory. First, is the ability to meet unexpected demand in all of its forms and second, is to take advantage of discounts in the cost of materials. There are costs associated with having an inventory and it is important that these inventory costs be weighed against transportation costs and other costs associated with materials procurement.

Noon (http://northstar.bus.utk.edu/mgt301/slides/ch10.html) states that there are three costs associated with having an inventory: the carrying cost, the ordering cost, and the shortage cost. The carrying cost is the cost of keeping an item in the inventory. The ordering cost is the cost associated with restocking inventory, and the shortage cost is the loss of sales when demand for a particular product cannot be met because of a lack of a raw material. In order to successfully manage an inventory and determine when and how much of a material needs to be ordered, inventory tracking methods are employed.

Inventory tracking is a critical process in a manufacturing plant. Waters (1992) asserts that manual methods of tracking can be employed, but there are also several different automated systems now available. He confirms that manual tracking can be a tedious system, for the obvious reason that higher volumes of stock being shipped and received will take a lengthier period of time to record.

According to Waters (1992), the purpose of holding stocks is to safeguard against fluctuations in supply and demand. Inventory tracking, which is used to ensure that there will always be sufficient stock on hand, is a complicated process that involves many factors. He explains that there is a balancing act between the costs of holding stock versus the costs associated with stopping production and losing sales. The flow of stock can be tracked as follows: stocks are delivered from the supplier; stocks are broken down into small units and stored until needed; customers place orders for items and stocks are removed; at the appropriate time another order is placed.

Due to the inequality of production rates and consumer demand it is often necessary to stock extra inventory items, says Waters (1992). He lists the following reasons supporting the argument. Safety stocks act as a buffer between operations of a production line, allow for incongruity between supply and demand, and allow for delayed or insufficient deliveries. In addition, safety stocks prevent delays in delivery to customers, take advantage of price discounts for large orders, make full loads to reduce transportation costs, provide a blanket for emergencies, and maintain stable levels of operations.

Typically, says Nahmias (1993), the measures of the efficiency of the inventory system include: amounts of stock held; the cost of holding it; how often shortages occur; how frequently stock is turned over; and the service level to the customer. According to several authors, service levels are defined as the proportion of customer demand, which is met from stock, and this is directly dependent upon the amount of stock held. With small amounts of stock, demand often cannot be met and there are periodic shortages. With high volumes of inventory, there is a lower frequency of shortage, but an increase in stock holding costs.

Many authors agree that there are three main questions to be answered when managers attempt to determine how to control an inventory system. These are, what items should be stocked? When should the orders be placed? How large should the orders be? In our case, the items to be stocked are predetermined by GE, so we will limit our discussion to the remaining two questions.

Waters (1992) suggests that there are three methods by which to determine when it is time to reorder stock. First, there is a periodic review system in which orders are placed at regular intervals, allowing for last minute changes in order quantity depending upon anticipated demand. Secondly, a fixed reorder quantity can be determined such that when stocks drop below a specified level an order is placed. This method allows for fluctuation in demand by enabling orders to be placed on flexible intervals. Thirdly, time and quantity of orders are based solely on known demand. According to Waters, it is necessary to consider the following factors for any of the above systems: details of the inventory system being used; type of materials being ordered; amount of demand for particular items; value and associated holding costs of items; costs of placing orders; lead time between placing and receiving orders; and supplier location and reliability.

Waters (1992) asserts that the best order quantity is dependent upon demand patterns; price of the materials, including discounts for large orders; cost of placing and receiving orders; cost of holding stock; cost of shortages; and delivery rates. He speculates that the correct combination of these factors can drastically reduce the incurred costs associated with inventory.

In order to balance the factors driving a company's decision about when to reorder, and in what quantity, Nahmias (1993) identifies the Economic Order Quantity (EOQ). He describes the model as the simplest and most fundamental of all inventory models. For the basic model, the following assumptions are made:

1. The demand rate is known and is a constant K units per unit time.
2. Shortages are not permitted.
3. There is no order lead-time (items arrive precisely when they are ordered).
4. The costs include:

   Setup cost C per unit ordered

   Proportional order cost p per unit ordered

   Holding cost h per unit held in stock

Because the lead-time is nonexistent, we can neglect calculation of the time at which we must order, and focus only on the quantity ordered. The size of the order will be denoted as Q. Due to the fact that the order is placed when inventory equals zero, we can say that the average size of stock being held is Q/2. And it follows that the average cost per unit time, G(Q) is given by

$$G(Q) = \frac{C + pQ}{T} + \frac{hQ}{2} = \frac{C + pQ}{Q/K} + \frac{hQ}{2} = \frac{CK}{Q} + Kp + \frac{hQ}{2}$$

From this equation we wish to find the Q that will minimize G(Q) and yield the minimal cost of ordering and holding stock. By differentiation we arrive at the optimal order quantity of

$$Q = \sqrt{\frac{2CK}{h}}$$

To fully optimize this equation, lead times and discount shipping rates for larger quantities must also be considered.

Inventory Tracking Methods

Sabath (1998) speaks of current automation tracking systems, which allow inventory tracking to be done by bar-codes located on the materials, and can drastically reduce the time invested in the process. He affirms that without an efficient tracking system, there can be serious adverse affects on the lead times of shipments, causing an increase in cost to the purchaser. Sabath (1998) concludes that in an effort to reduce shipping costs, it is necessary to have an accurate system for tracking the quantities of stock on hand, in order to avoid incurring extra costs for expedited shipping.

A manual method for tracking inventory, proposed by Waters (1992), is the two-bin method. In this method, stock is kept in two separate bins. When the first is empty, it is time to reorder the product, and begin taking stock from the second bin. He qualifies this method by stating that it is necessary to first assess the amount of stock that will be needed in the time that it will take for the shipment to arrive and ensure that this amount of stock is kept in the second bin. This method is similar to the Kanban method employed by the GE plants in Puerto Rico.

Safety Stock

Safety stock is important, according to Waters (1992), because it determines the optimal amount of raw materials to be stored in inventory so that there is no excess or shortage of raw materials for production. In theory, if the demand forecast is accurate the safety stock will never be needed. However, in practice the demand forecast is almost always less than accurate. In order to determine the optimal safety stock quantity, a mathematical model can be used which utilizes probability. Probability is a factor in this model because of the uncertainty associated with demand. This model is useful because it shows the advantages to storing one more unit of a raw material, given in terms of cost. The model also shows the disadvantages to storing one more unit of a raw material, which are given in terms of marginal expected losses. The same is done for the advantages and disadvantages of storing one less unit of a raw material (Nahmias, 1993). The objective of the method is to continue increasing the amount of safety stock by one unit, until the benefit of carrying the extra unit, equals the cost associated with carrying it.

Transportation Costs

Carter and Ferrin (1996) state that historically the supplier has not managed transportation costs. These costs are not included as part of the unit price for shipping and are not part of the order preparation costs. They stress that a company handling large transportation costs should manage all inbound transportation costs as a separate factor in their cost analyses. The oversimplification of transportation costs by the recipient company when analyzing a financial situation may put a firm in the hands of its suppliers. Since the suppliers are not affected by these transportation costs, it is not advisable to let them assist in lowering costs to the firm.

Several sources agree that there are various ways of reducing transportation costs. McGovern (1998) suggests other possible methods of reducing these costs are through better management of scheduling procedures. He points out that by evaluating the current scheduling procedures for an individual firm, money can be saved by avoiding the need to ship products at the last minute. He also observes that last minute shipments will be a significantly higher cost to a company due to overnight shipping charges. McGovern also makes the important point that by utilizing a software scheduling system a company can avoid last minute shipments, increase its productivity, reduce its labor force, and increase its customer service.

In his article, Richardson (1994) conveys that another issue that has affected industry is the changing environmental aspects of transportation. He states that a company must have safe and environmentally accommodating services, and through these environmental changes the company can increase its competitive position.

Traffic Management Journal (1990) states that dealing with one specific carrier can also reduce cost. In doing this, a contract can be negotiated between carrier and recipient that will benefit both parties. The journal points out that three key factors need to be observed when negotiating a contract for transportation with a supplier. These factors are as follows: "the unit price for the product; the order quantity used; and the supplier's guaranteed lead time, from placement of a replenishment order to its shipment date." (Traffic Management, 1990) In order to cut costs using negotiations, "win-win negotiations" are used, meaning that the objective is to find an arrangement where both the company and the carrier benefit from the business affiliation by compromising with each other (Traffic Management, 1990). In order to do this, *Traffic Management Journal* believes that the firm first must describe its service needs, which will assist in determining the number of carrier options that it has. Determining their carrier options will make the variety of possible transportation arrangements more apparent, and the process of negotiating with carriers can begin by sharing all necessary information with the carrier. By doing this, the carrier can determine if accommodations with the firm can be made utilizing existing services.

Another method of reducing a business's transportation expenses, discussed by Sayre (1995), is to focus on different methods of transporting goods. He states that a recent development in ocean transportation is cutting ocean delivery time by over one half, while remaining significantly more cost effective than airfreight. Sayre (1995) points out that in some cases, airfreight can cost between seven to ten times as much as ocean freight. With the new development of FastShip™ the option of ocean transportation becomes more appealing. FastShip™ is described by Sayre (1995) as, "…an integrated, intermodal transportation service that provides unparalleled frequency, speed and reliability…."

Case Studies

According to Carter and Ferrin (1996), various companies have been successful in lowering their transportation costs significantly by paying more attention to scheduling, methods of transportation, packaging, and other alterations to their procedures.

Carter and Ferrin (1996) cite GTE as an example of a company that provided procedural alterations. GTE spent $84 million dollars on transportation alone in 1993, which was GTE's second largest cost for that year. After studying their suppliers' freight invoices the widespread use of free on board (FOB) destination terms were found to give suppliers the opportunity to markup prices up to 60 percent on the charges for shipping and handling. In reaction to this discovery, Carter and Ferrin (1996) report that GTE Supply now requires that all shipments be sent FOB origin. Due to this adjustment GTE is now saving $40,000 in transportation costs per day.

As reported by Carter and Ferrin (1996), in order to lower transportation costs, Toyota Motor Company plans for a strictly scheduled delivery of goods into its plants several times per week. Containerized goods travel first by sea from Japan to Washington state. A train then transports them into the Toyota plant in Georgetown, Kentucky. By avoiding air travel, Toyota saves significantly in costs, but suffers in speed of delivery. Carter and Ferrin (1996) report that in order to compensate for this, the manufacturing schedule must be balanced to arrange for consistent transportation volumes. Toyota must also be constantly updated on the status of their shipments and keep strict records of any specifications, problems during shipping, and container loading patterns (Carter, Ferrin, 1996).

Carter and Ferrin (1996) also speak of the Lever Brothers Company, which early in 1991 developed a group that would study inbound transportation in its distribution division. The group found that due to the overuse of terms such as "prepay" and "add" in their freight terminology, Lever Brothers was very susceptible to arrangements being made between the supplier and the carrier off of the bill. It was decided that the company must take control of selecting the carrier for its inbound transports.

General Public Utilities reduced its inbound freight costs by over half a million dollars in only six months, according to Carter and Ferrin (1996). By implementing a logistics program to control inbound transportation a plan was devised to convert from FOB destination, to FOB origin. Also involved was the process of universalizing freight terminology, and convincing management to make a commitment to supply the resources needed in order to control freight costs separately from costs of materials.

By looking into the case studies of the previous firms, it becomes apparent that in order to manage inbound transportation costs it is necessary to have an effective logistics management program. Inventory management alone does not equate to efficient control of transportation costs (Carter, Ferrin, 1996).

Just-In-Time Manufacturing

Just In Time (JIT) is another waste-reducing method of raw material purchasing that can be implemented in manufacturing, according to Cheng and Podolsky (1996). They state that the overall goal of JIT is to not only eliminate waste, but also to determine which processes are contributing the most to waste accumulation. Waste in this sense is any process that has an associated cost, but does not increase the value of the finished product. According to several authors, there are seven major contributors to waste accrual:

1. *Over-production* – When a company is not operating on a demand pulled basis, it can produce products that are not required, wasting resources and work force time. Overproduction can also result in untimely break down of machinery due to overuse.
2. *Excess handling* – The waste incurred with excess handling is a loss of efficiency on the part of the workers handling materials that are to be used in overproduction.
3. *Movement* – Poorly designed plant layout can cause excess transportation between workstations.
4. *Processing* – Production of parts that do not contribute to the value of the finished product.
5. *Holding time* – Inventory time spent in transit or in warehouses, instead of on the production line.

6. *Defects* – Sources of defects cannot be detected when only the finished product is examined. It is necessary to track the progression of production to eliminate wastes incurred by producing defective goods.
7. *Inventory Costs* – Excess production often requires excessive inventory stock, which causes risk of obsolescence, damage, and increased storage costs of raw materials.

Pull System

Cheng and Podolsky (1996) state that the pull system is a JIT process that attempts to eliminate accumulation of the wastes referred to in the above section. They say this method is founded upon the ability to forecast demand, and is a customer oriented manufacturing system. The two goals of the pull system are the redirection of production flow and prediction of the appropriate amount of finished goods (Cheng and Podolsky, 1996, 46). According to several authors, one advantage of this system is the ability to keep a low level of inventory. In addition, customer satisfaction is increased due to the ability to meet demand without the price increases associated with over-production. The corresponding drawbacks are the lack of flexibility in production planning, and the difficulties that arise with the attempt to produce a wide range of products. A method referred to as the 'hybrid method,' can reduce the impact of these drawbacks, by indicating which parts are required for specific goods, and tracking them individually.

Just-In-Time Case Studies

Utilizing JIT principles, Cook (1996) declares, the effectiveness and efficiency of continuous manufacturing processes can be considerably improved. Through the elimination of waste and developing an improvement in continuous productivity throughout the entire manufacturing process, a successful JIT program can be introduced.

Cook (1996) gives a case study on the Dow Chemical Company, who first began using a JIT process in 1993, in order to improve performance in their North American supply chains. He reports that after selecting a specific method in which to implement the JIT process, Dow chose one specific aspect of the supply chain to concentrate on by analyzing all their current procedures and determining which ones could benefit most and be successfully altered. Cook (1996) describes how Dow then studied inventory waste and analyzed the routes of a supply chain involving another company in Michigan and successfully lowered their costs. They improved their forecast accuracy by 25 percent, their average distribution lead-time by 25 percent, and their distribution lead-time variability by 50 percent. These improvements immediately resulted in savings of close to $900,000 and are still providing for savings of $170,000 per year, according to Cook (1996).

Human Resources-Resistance to Change

The sociological side of our IQP dealt with human resources and the resistance to change of employees in a particular organization. In our case this organization was General Electric's Puerto Rican manufacturing plants. The resistance to change that our group encountered was caused by measures that we proposed in order to reduce the inbound transportation costs incurred by GE.

When implementing a change within a company, people react to this change in some manner. According to Jones (1987; 16) there are four possible reactions to this change. These are as follows:

1. Resistance to change
2. Denial with respect to the changes taking place
3. Reacting negatively to the proposed changes
4. Believing in the proposed changes and accepting them

In order to give the reader a better understanding of the importance of being prepared before a group undergoes a change; Jones (1987; 17) gives the analogy of having open-heart surgery. Open-heart surgery will cause a major lifestyle change for the patient. Before undertaking open-heart surgery, one needs to ensure that they understand the importance of the changes and weigh them against not making any changes. Also, the patient in this case would want to make sure that the surgeon performing this surgery was qualified and that his staff was also qualified. Jones applies this to organizational change by stating that before implementing a change, one needs to make sure they understand the importance of the changes and then weigh them against not making the proposed changes. In addition Jones states the importance of having qualified individuals implement the changes in order to ensure both completion and success.

In addition to the heart surgery analogy, Jones (1987; 18) states that before undergoing change in a particular area of an organization, the group performing this change needs to research the history of the company and also the environment which caused the particular area of the organization to operate the way it does. Once this is understood, the group performing the implementation will complete it more effectively and also anticipate any problems that might occur. In addition to the organization's history, company policy as well as pressures that may arise must be taken into account. Company policy must be considered in order to implement change effectively. If company policy is not followed, the proposed change may either be rejected, or implemented incorrectly. In either case, the maximum benefits of the proposed change cannot be achieved.

Jones (1987; 27-28) explains that pressures, which arise when implementing an organizational change, may either be internal or external. An example of internal pressure is when managers push for immediate results in an organizational change that was meant to be long term. The other type of pressure, external pressure, can be caused when a company pressures its suppliers to undergo the same organizational change it is implementing. A company may threaten that if the supplier doesn't implement this change they may no longer do business with the company.

Both Gilmer and Deci (1977; 356) state that resistance to change can be caused by several things. The major cause of this resistance is uncertainty. This uncertainty takes various forms. The following are two examples of this uncertainty. The first is an employee being uncertain as to whether or not he or she will keep his or her job once the proposed change is implemented. The second example is uncertainty as to whether or not one will keep one's current job. There is also uncertainty regarding whether or not they will like their new job, after the changes have taken place. The group that is responsible for implementing the change will need to take these uncertainties into account and try to eliminate them as much as possible.

One method that was proposed by Gilmer and Deci (1977; 356) is to invite those that are being affected by the change to be involved in the implementation process. Another method that was discussed by Gilmer and Deci (1977; 356) and can be implemented in order to reduce resistance, is to stay away from the more traditional authority structure which emphasizes obedience and competitiveness and move towards a more group oriented structure with shared responsibility. According to the authors, this does not mean that all authority and leadership is eliminated, but just enough so that resistance to change is minimized.

Chapter 3 METHODOLOGY

Analysis of Data

The first step taken after researching relevant background topics was to analyze the manufacturing plant cost data provided to us by our liaison. The data was contained in a Microsoft Excel spreadsheet that provided information on each transaction between a plant and supplier involving air transportation during the year of 1999. Data such as supplier, destination plant, weight of shipment and cost of air transportation was included, along with various other data.

Utilizing this data our project team calculated the total dollars spent on materials air transported by each plant and by Caribe GE as a whole during this one year. After this we also determined the number of air shipments that occurred during the year of 1999, once again determining these by plant and by all of GE's Puerto Rico operations.

With this new data we determined the plants that spent the most on air transportation during 1999. These plants were found to be Patillas, Arecibo, Vega Alta, and Vega Baja. The plants that spent the least on air transportation with a correspondingly high total product output for the year of 1999 were also determined. These plants were the facilities in Humacao and Palmer. Further information about the transportation costs and the number of air shipments for 1999 of the Caribe GE plants is given in **Table 3-1, Table 3-2** and **Figure 3-1**.

Plant	Dollars in Thousands	Percent of Caribe GE Total
Bayamon	$20.43	1.25%
Vieques	$29.52	1.81%
Palmer	$55.68	3.42%
Humacao	$66.55	4.09%
Añasco	$69.72	4.28%
San German	$75.93	4.66%
Vega Baja	$142.06	8.72%
Arecibo	$145.39	8.93%
San Juan	$175.02	10.74%
Vega Alta	$201.57	12.38%
Patillas	$646.82	39.71%
CARIBE GE TOTAL	**$1628.69**	100.00%

Table 3-1 Total Dollars Spent on Air Transportation in 1999

Plant	Number of shipments	Percent of Caribe GE Total
Palmer	437	1.80%
Vieques	611	2.52%
Bayamon	739	3.05%
Humacao	907	3.74%
San German	1195	4.93%
San Juan	1535	6.33%
Vega Baja	1873	7.72%
Añasco	2248	9.27%
Vega Alta	2617	10.79%
Arecibo	2841	11.72%
Patillas	9247	38.13%
CARIBE GE TOTAL	24250	100.00%

Table 3-2 Total Number of Air Shipments for 1999

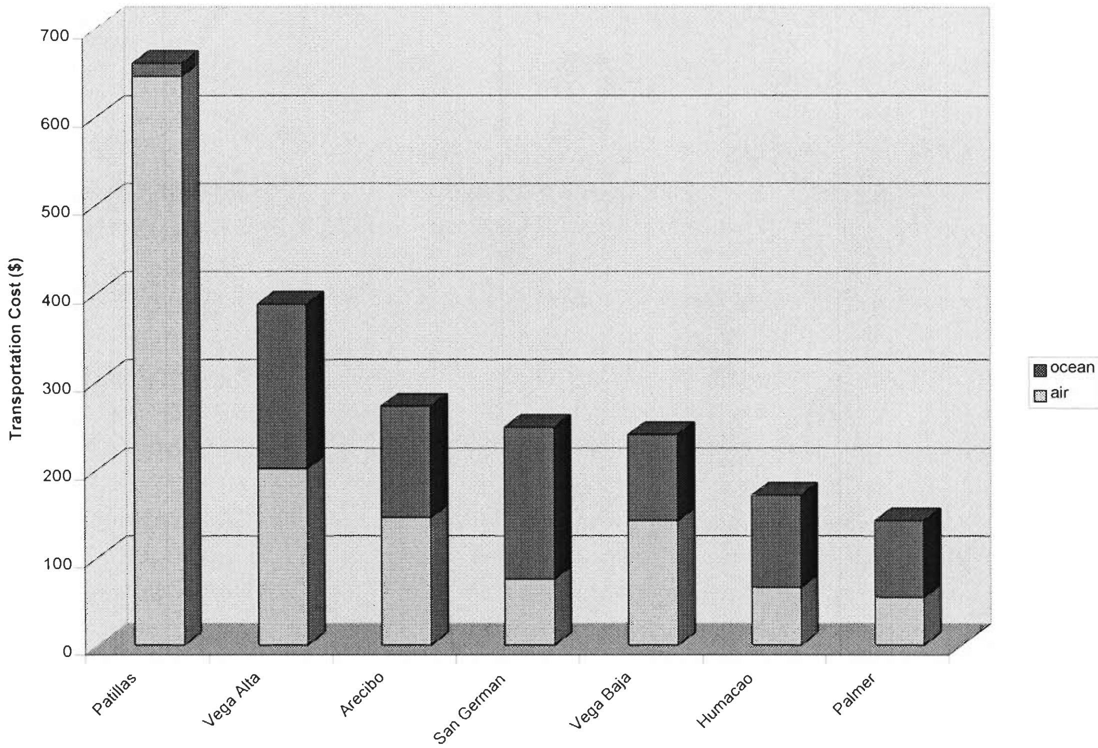

Figure 3-1 1999 Ocean and Air Transportation Spending by Plant

Figure 3-1 displays the total transportation costs of the plants for which data was available. The data was given to us by the Transportation Leader in the Bayamon Sourcing Office. We then created the figure to illustrate the percentage of ocean and air transportation services being used at each manufacturing facility. As depicted by the graph, Patillas, Arecibo, Vega Alta and Vega Baja had the highest ratios of air transportation vs. ocean transportation spending.

Our next step was to breakdown each plant by supplier to determine which suppliers were contributing the most to each plants air shipments. In doing this we focused on two factors: the total spending of each plant by supplier, and the frequency of air shipments by supplier.

In analyzing the total spending by plant we generated a list of costs per supplier to enable us to further investigate the particular suppliers and the materials they are transporting. Various hypotheses were developed about the reasons for the high costs associated with these suppliers, such as the value of the material being high, or the safety stocks for these materials being insufficient. Factors we examined were distance, weight and nature of materials being shipped.

We then examined the frequency of air shipments per supplier, because in some cases there were multiple shipments being received each day from a single supplier. In doing this we took the same factors as were previously used into consideration.

Utilizing the information discussed above, we compiled a list of suppliers about whom we spoke to each of the materials managers in order to determine the causes for the high frequency of air shipments. We also wanted to identify any suppliers that were providing materials required to be shipped by air. In cases such as this our goal was to move the shipping method from next-day air to economy or second-day air.

Preparation for Interviews

In order to prepare for the interviews to be conducted at each manufacturing plant we spoke with several individuals in the Bayamon headquarters office and developed a detailed list of questions for the personnel at each plant.

In speaking with the personnel at the Bayamon office we hoped to identify specific procedures that should be focused on during our visits to each plant. We also wanted to find out if there were specific individuals from each plant who were placing abnormally high numbers of air shipments.

The purchasing personnel in Bayamon were able to give us an overview of the ordering process that the manufacturing plants should be following. They explained that orders are pulled from a system called Oracle, and that these orders are then sent on to the suppliers. For expedited shipping it is also necessary to have a faxed copy of an air authorization form, signed by either the materials or plant manager at each plant. A sample copy of this form is included as Appendix B.

The transportation personnel at the Bayamon Sourcing Office gave us a print out of the company protocol regarding air shipments. The document listed the weight, method of shipping, and the specific carrier that should be used. This document is provided in Appendix C. Caribe GE has developed an agreement with Caribbean Air, making it significantly cheaper to utilize their services for some shipments. Federal Express and Emery are also used in some cases. The ideal method for all but a few materials is ocean transport through the consolidation point in Union, NJ. After that, air services provided by Caribbean Air or Eagle Global Logistics is preferred, followed by second and next-day premium services of Federal Express and Emery.

The Materials Leader at the Sourcing Office gave us information on the Materials Managers at each plant. These individuals, who were the key people we spoke to at each plant, oversee the entire production process including receiving, warehousing, production and distribution. We hoped to obtain a clear understanding about the processes each plant was following from these managers. Specific aspects we focused on included inventory tracking, safety stock quantities and lot sizing.

After speaking with personnel in Bayamon, we began determining what information would be needed from manufacturing plant personnel. The main point of interest to us in each of the plant interviews was determining the reason for the frequency of air shipments. It was our hope that the answers gleaned from this inquiry would allow us to determine what the problems at each plant were, enabling us to address them accordingly.

Lead times of suppliers were determined to be important information that we would obtain on our plant visits. Our specific objective was to determine whether or not the buyers were aware of the total time it would take to have materials sent from the vendors, to the consolidation point in Union, NJ and then shipped via ocean to Puerto Rico. The goal in verifying this was to determine if there was a problem with lead times because of a misunderstanding about the time required for this process. If we found this to be true, then we could address this issue to allow sufficient lead times for supplies to be shipped via ocean.

We also wanted to determine the current safety stock quantities for the materials being stored at each plant. The amount of safety stock being held would tell us how long normal production could continue if the normal inventory was exhausted for any reason. From this, we could determine whether or not the plant had a sufficient amount of materials to continue normal production while inventory is in transit. This means a safety stock of two to three weeks would be necessary for materials that have high demand if the materials were to be sent through the consolidation point.

Inventory tracking was another topic that we investigated during our plant interviews. We developed a hypothesis that the basis of the problem at each of the plants was within their inventory tracking methods. In order to determine what these methods were, we decided upon which processes we would target to determine their efficiency. We chose to focus on the processes of materials being tracked from the receiving area, to the warehouse, and then throughout the production floor.

Another key component of the inventory process that we wanted to examine was the lot sizing model being used. Depending upon the cost of placing orders and holding inventory, as well as lead times for suppliers, the order quantity could vary drastically. It was our intent to determine what software or process they were using to calculate this order quantity so that we might be able to examine its accuracy.

After speaking with our liaison we became aware that air authorization procedures being followed by each plant were significant to our investigation. Many plants were not complying with company protocol, and it was our goal to determine what procedure each plant was following.

Once we determined what information we wanted pertaining to the processes of each plant we had to determine which plant personnel to contact. Our liaison assisted us in deciding upon the following individuals:

- *Materials Managers* – These people are in charge of the complete flow of materials in the plant. They track materials from receiving through production to distribution. We hoped to receive an overview of the entire production process from them, in order to better understand each plant's practices. This information was also used to verify that the procedures they explained to us were being followed by the planners at each plant, including the procedure of completing air authorizations, which are approved by the Materials Managers.

- *Materials Planners* – These individuals work with the inventory of each plant, and are known within GE as Production and Inventory Control (PIC) Owners. Their job varies slightly by plant, but generally they check the accuracy of the inventory tracking system, as well as place all orders for the plant. Depending upon the plant, their material responsibilities are broken up by either production line or commodity. We spoke to them regarding their ordering procedures both in general and with specific suppliers.

Formulate Questions for Plant Interviews

After speaking to the personnel in Bayamon, we began formulating questions for the Materials Managers and Planners at each plant. The questions outlined the production process from the receipt of customer orders, to the placement of materials orders through the receiving process, production, and on to shipping. The intent of gathering information about each step of the process was to locate any troublesome procedures, or any areas that may be causing inaccuracies in the inventory count, both of which could result in a shipment being expedited.

After formulating our preliminary set of questions, our liaison evaluated them thoroughly and gave suggestions on what could be changed to enable us to gain all of the information we wanted. The final list of questions appears in **Table 3-3**.

- Who are your suppliers? customers?
    - How do you receive orders from them?
        - Is there a standard form to be used, do they call you, are orders placed electronically?
    - Who actually receives the orders, and what is the process?
    - Do they make special requests?
        - Are the products standard or can they be varied?
            - At what point in production does the product change from being standard to specialized?
        - What is the impact of this on the production schedule?
            - What is involved with changing the product line?
    - Can this demand be predicted?

- What is your production schedule based on? (ex. Past demand)
    - How do you forecast how much of a given material you will need a month?
    - How far ahead can you tell when you will need a given material?
    - How often does your production schedule change?
        - What types of variations are there?
        - How much does it change? Drastic, or minor?
    - What are your parameters for rescheduling? (What factors does it depend on?)
    - How much time does the customer give you to complete orders?

- What type of a production schedule are you running? (JIT or another type)
    - How does this affect how much material is kept on hand?
    - Where is the material kept if it is kept on hand?
        - If materials are not kept on site, where are they kept?
    - How long after a material arrives on site can it be used in production?
        - How are materials added into the inventory system?

- How do you calculate what size safety stock to hold?
    - What variables do you take into account when you calculate safety stock?
    - Do you have on record how many completed units are you capable of producing with your safety stock on hand for each material?
        - Is this stock sufficient to allow for ocean transportation of the materials?

- Can you describe the process of a material being ordered (including how somebody realizes that it needs to be ordered), shipped, received, and put into production in detail from start to finish?

Table 3-3 Plant Interview Questions

- What is the re-order process?
    - Who is first aware of the need for a material?
    - Who does this person notify, and what is the authorization process if expedited (air) shipping is required?
        - Who specifically authorizes these air shipments?
            - Does this individual stick to a budget, or are all requests granted?
    - When you re-order do you qualify the parameters? How do you set the mode of transportation and the time that it will take to ship?
    - When ordering a material, do you take lot size into account?
    - If so, how do you calculate lot size?
    - What variables are taken into account?
    - What are your current ISO standards for shipping raw materials?
    - Do you know your ABC values, and how closely are they followed?
        - How is the ABC analysis done?
        - What percent of each material do you bring in? Is there one specific material that is ordered most frequently?
    - Could you run through an order cycle with us?
        - Can you give us examples of worst, best and normal orders? (Worst ~ running out of materials, Best ~ having all materials and no line changes needed)

- What are your Air Authorization criteria?
    - Is there a material value/transportation cost ratio that is considered?
    - Are the total number of air shipments per plant or line tracked to be sure that specific lines are not over-spending?
    - What are the factors involved in the decision to send materials by air?

- What procedures do you normally follow when determining how to ship materials?
    - Bring up the sheet from Joe.

- Do you have predetermined lead times for each supplier (or at least reasonable estimates)
    - How closely are these followed when planning on when to order a given material?
    - Are there any suppliers that primarily use air transportation, and if so why is this?

- What type of materials do the high volume suppliers provide, and does this have a correlation with these suppliers being used so frequently or having such a high air transportation cost?

Table 3-3 Plant Interview Questions

- How does your inventory management system work?
    - We understand that there is an MES system in place at a couple plants. Are you currently using this, or will you be in the future?
        - Could you tell us about this system?
    - Can you predict when you will run out of a material?
    - How are you notified that a material is out of stock?
    - How do you know when to order more of a material?
- Can you think of any possible explanations for materials running out? Is there a specific fault or glitch in the inventory system?
    - When you need to use expedited shipping, what is typically the cause?
        - Is it the fault of the supplier?
            - What is the procedure for paying for expedited shipping, when it is the fault of the supplier?
- Is the system user-friendly?
    - Are there problems with the way the system is currently?
        - What suggestions can you make to fix these problems?
- If it were your money, how would you change the process to save money?
    - What issues do you encounter frequently?
        - How might these be resolved?

Table 3-3 Plant Interview Questions

Conduct Plant Interviews

When making appointments to visit the Caribe GE manufacturing plants we decided that it would be best to first visit a plant that we believed had satisfactory materials management procedures in place. After examining our findings at this low spending plant we visited plants that were spending significant amounts on air transportation. Each plant's materials processes were observed and evaluated individually in order to create a best practices procedure that could be implemented island wide.

Humacao Plant

The first manufacturing plant that we decided to investigate was the plant located in Humacao. Humacao was selected because it was a plant with a very low air transportation cost. It was chosen over other plants with low air transportation costs such as Palmer or Vieques, because the air transportation costs in Humacao were the lowest when compared with their volume of production. It was our hope that by observing the practices taking place at this plant we would have a better understanding of what to look for when visiting plants with high air transportation costs.

Upon arrival at Humacao we were introduced to the Materials Manager, and to the two Planners. We gave the Materials Manager a brief summary of what processes we were interested in finding out about as well as a general overview of the project. We then toured the facilities in order to gain a better understanding of the physical flow of materials through the plant in addition to a an understanding of what types of products were being made and what materials were being kept on hand. During the tour we focused on the layout of the plant and the process involved in tracking inventory through production to determine how the process was being managed and what procedures could be applied at other facilities.

Following the plant tour, the two Planners joined us in a conference room and we gave them an outline of our project, making note of the specific processes we were interested in. We then interviewed the first of the two Planners, following the questions included in **Table 3-3**. From this interview a great deal of information specific to our topic was gained, including details about procedures specific to Humacao. The focus of the interview was on the inventory system being used, as well as the system that is scheduled to be implemented in October of 2000.

The air authorization procedure was also highlighted, with the intent to ensure that both the Planners and the Materials Manager were in agreement about the procedure that should be followed. After having been alerted by our liaison that air authorization procedures were not consistently being followed, we wanted to determine whether or not all personnel were even aware of the proper procedure. Upon determining this, we wanted to ensure that both the Planners and the Materials Managers were in agreement about the process, and identify any procedures that may be specific to Humacao due to the characteristics of the materials being ordered. It was our goal to determine whether or not there were materials shipped by air as a default because of fragility or value.

Upon completion of the interview with the first Planner we recorded some preliminary notes and began the interview with the second Planner. To ensure that the same information was highlighted in both interviews, the same person acted as interviewer in both. The other two members of the group recorded information, supplying clarification to questions when needed and asking additional questions in areas where responses were unclear. After completing the interviews in Humacao we immediately documented the information that we obtained regarding their practices and procedures.

Patillas Plant

Subsequent to the interviews at Humacao, we interviewed personnel at the Patillas facility, focusing on the procedures outlined above in order to gain an understanding of what processes might account for the high air transportation costs at that plant. Patillas was chosen due to the extremely high cost of air shipments ordered in 1999. The Patillas facility had the highest number of air shipments of any of the ten Caribe GE plants.

The visit began by meeting the Materials Manager and his assistant. Following the brief introduction and an explanation of our project we were taken on a tour of the facilities, taking note of where materials were being received, stored, and shipped. Again it was important to gain an understanding of what products were being manufactured, as well as the type of raw materials used in production. This was done in order to determine if Patillas was ordering materials which must be flown by air due to fragility, value or size.

The first of three Planners was interviewed directly after the tour of the facilities. Following the established interview format, we attempted to determine if there were any materials each of the Planners dealt with that needed to be flown by air because of special concerns. Throughout the Patillas interviews the questions were more focused towards the reasons for the high frequency of air shipments than at the Humacao plant. Each of the Planners provided explanations specific to their production line as well as general statements about what the causes might be. From each Planner we obtained information regarding the procedures for air authorizations and found that there were exceptions being made to the established company protocol.

The Materials Manager met with us once we completed the interviews with the Planners. From him we received a specific outline of the production and inventory procedures. He answered several questions that had come up during the interviews with the Planners and arranged for a tour through the shipping and receiving areas, as well as the stockrooms. Following this tour the visit was concluded and we documented the data gathered.

Arecibo Plant

The third plant we visited was Arecibo, the plant with the second highest air transportation costs in 1999. At this facility we met with both the Plant Manager and Materials Manager to give an overview of the processes we would like to examine. Both managers led us on a plant tour, beginning with the receiving area. From that location, we were given a tour through the rest of the plant, again paying attention to the locations of materials being stored and the way that inventory is accounted for while in production.

After the plant tour we met with three of the Planners. We presented them with the list of suppliers who shipped the highest number of materials by air in 1999 and asked what possible explanations they might have. In addition to this, detailed explanations of the inventory tracking, ordering and air authorization processes were given. One Planner also demonstrated the placement of an actual order to us, clarifying each step of the process as it was carried out. This concluded our plant visit and all information gained was recorded and discussed.

Vega Baja Plant

Vega Baja was the next plant that we paid a visit to, this facility also had a high frequency of air shipments in 1999. The visit began with a tour of the plant that gave us a good overview of the products being produced there along with general information about their shipping and receiving procedures. Following this we spoke with the Materials Manager in order to gain a better understanding about the procedures that were being carried out in regards to material forecasting, ordering, tracking, and various other processes.

After a short break that we used to prepare for the remaining interviews we met with two Planners individually for a short period of time. From each of these people we gained information about air authorization procedures, specific suppliers, and ordering procedures. Following the two of these interviews we left the plant and once again met to document our data.

Vega Alta Controls Plant

Vega Alta was the last plant visited, and was the plant with the third highest frequency of air shipments. Our visit to the Vega Alta Controls Plant began with a brief meeting with their Materials Manager. In this meeting we presented him with the basis of our project and the background information that we were looking to obtain. We then met with two Production and Inventory Control Owners and questioned them about specific issues that we were interested in. Following this we once again met with the Materials Manager and furthered questioned him in order to gain a clearer understanding of the processes within the plant. The Materials Manager then led us on a plant tour so that we could better understand the processes that we had been speaking about. After leaving the plant, the information obtained from the interviews was documented. This concluded the plant interview procedure. The complete report of information gained in these interviews is included in Chapter 4.

Establishment of Best Practice Procedures

Following the completion of plant interviews we compared plant procedures to determine the best practices of each plant visited. Practices pertaining to safety-stock, Kanban sizing, re-order quantity and air authorization procedures were targeted and compared. The recommendations based upon our findings can be found in Chapter 4.

Analysis of Transportation Data

Once we determined what our recommendations to the plants were, we began to analyze the transportation data given to us by our liaison to create a solid foundation for the solutions we proposed. The basis of our recommendations was an increase of both safety-stocks and inventory.

Several planners conveyed to us their belief that shipping materials by air was often cheaper than holding them in inventory when the demand for the materials was especially sporadic. In order to aid planners in determining when materials ought to be held in stock as opposed to flown by air we created a graph with material values and weights and associated transportation and inventory carrying costs for next-day and second-day air shipping. These graphs are included in Chapter 6 and illustrate the point at which inventory carrying costs equal transportation costs for a given period of time, as determined by material weight and value. From these graphs it can easily be determined how long a material must be held in stock in order for the inventory carrying costs to exceed the transportation costs associated with air shipping. If the planners determine that materials must be held longer than the specified period of time before there will be a need for that material, then air shipping is advisable. Otherwise materials should be held in stock until there is a need for them in production.

Formulation of Conclusions

After determining the best practices of the manufacturing plants visited, and performing our cost analysis of carrying larger inventory versus transporting materials by air, we formulated guidelines which should be followed at all plants regarding air authorizations and ideal inventory levels. These recommendations comprise Chapter 7, and are supplemented with suggestions for control systems to ensure compliance.

Chapter 4 **RESULTS**

Introduction

Except for certain documented exceptions, the current accepted procedure for transporting material to the GE plants in Puerto Rico is to have the material sent via ocean. Caribe GE has established a consolidation point in Union, NJ where suppliers from the mainland United States ship materials to by ground transportation. At this location in Union the materials are loaded onto an ocean freighter and sent directly to San Juan, PR.

Prior to April 2000 two ships were being sent from Union each week, but GE now schedules only one departure per week. In order for materials to be sent via the ocean route they must arrive in Union by Thursday afternoon. The ship then departs on Friday, arrives in San Juan on the following Tuesday, and the materials will arrive at the plants on either Wednesday or Thursday. In order for the materials to arrive in Union on time from the supplier it is necessary to predict the land transportation time accurately to avoid missing the departure of the container ship. Because of the reduction in the number of shipments, if the departure is missed materials will now have to remain in Union for an entire week, or be sent by air to avoid production stops.

The ten manufacturing plants in Puerto Rico are currently utilizing software called Oracle to place material orders. At each of the ten plants, planners begin the requisitioning process by entering their requests for material into the computer system. This information is sent to the Sourcing Office in Bayamon, PR. The buyers at the Sourcing Office then run a process called "AutoCreate," which formalizes the requisitions into actual purchase orders. The purchase orders are then sent through a server in Fort Wayne, Indiana where one of the following procedures is followed. If the vendor's software is compatible with the Oracle system, a fax or e-mail is sent to them electronically using Electronic Data Interchange (EDI), which is a component of the Oracle software. If the vendor does not have the capability to receive these electronic transmissions the server in Fort Wayne prints the formal purchase order in the Bayamon Sourcing Office and the buyers fax them directly to the suppliers. The inventory tracking procedures that take place prior to ordering vary by plant and will be further discussed in the following sections.

Humacao

As previously stated, Humacao was the plant we chose to visit because of its low transportation costs in combination with its high volume of production output. In observing the plant procedures at Humacao, we were trying to gain an understanding of how inventory management, production scheduling and materials ordering can be successfully managed.

The visit began with a plant tour where we discovered that the majority of Humacao's inventory is tracked using a Kanban method in which parts are kept in several bins. The purchase planners, also known as Production and Inventory Control (PIC) Owners, check these stocks on a daily basis and when the specified number of bins are empty, an order is placed. In addition to this, two weeks worth of a material is kept on hand as a safety stock. In theory, the amount of inventory remaining when the order is placed should be a sufficient amount to allow for ocean transportation of the materials being ordered. The extra two weeks worth of inventory acts as a safety stock to prevent the need for air shipments in the event of an unforeseen emergency. Two weeks is sufficient time for newly ordered materials to be sent through the consolidation point and reach any Caribe GE plant. Therefore, with a two-week safety stock, even if the regular inventory has been exhausted, normal production can continue until the new shipment arrives. Judging from the low air transportation costs at Humacao, it seems that this system is working effectively for them. There is currently an initiative at all the Caribe GE plants to implement a new safety stock program called Crystal Ball that will recalculate the sizes of the safety stocks for all the materials that the plants are currently using. This will improve the calculation and usage of these safety stocks by factoring in variables such as the probability of unexpected increases in demand and lead time.

Another important factor that allows Humacao to minimize their air transportation is their heavy use of consignment. Consignment materials are kept in the stockroom in a separate section from the other materials and are checked weekly. When utilizing consignment the supplier owns the stock and it is their responsibility to pay for any transportation costs. The Planners report to the consignment supplier how much material has been used and the supplier then bills the plant for this material only. It is up to the supplier to calculate at what point more materials should be sent, based upon the usage reported by plant personnel and taking into account the two weeks necessary for ocean transport. Theoretically there should never be a need to air ship materials being supplied on consignment, though in other plants we found that consignment suppliers were actually sending materials by air more frequently than other suppliers. Humacao's procedures regarding consignment may be useful in lowering the transportation costs of some of the other facilities.

While visiting Humacao we also inquired about the air authorization procedures being followed. Each air shipment is authorized by either the materials or plant manager and the authorization forms are then sent to the Bayamon headquarters office. There are no materials that should be sent by air routinely except for silver powder.

The Humacao plant utilizes a report, known as the Production Scheduling Information (PSI) report, in order to forecast its production schedule. The PSI report is put out by the GE plant in Plainville, CT and is used to forecast the production at all the Caribe GE component plants. This report is updated quarterly by Plainville, and the Humacao plant further updates it monthly.

Patillas

The manufacturing facility in Patillas had very high air transportation costs in 1999, causing it to have the greatest opportunity for improvement. The plant is divided into two sections, one of which is produces drive system devices (DSD) and the other produces electronic vehicle controls (EVC). Their managers stated that Patillas is in a somewhat unique situation due to the volatility of its demand. They are not using the PSI report generated in Plainville because it is unable to forecast the proper demand for materials. Many of their finished products are standardized to a point and then customized for specific customer orders. While the forecast for the total volume of production is accurate, they cannot correctly determine in advance the number of customized products that will be needed. Due to this inability to forecast, Patillas is continuously exhausting their inventory and ordering materials via air. The Materials Manager at the plant told us that he and other plant personnel were currently exploring other methods of forecasting their production schedule. Proper forecasting of material needs will assist planners in ordering materials with enough lead time to have them sent through the Union consolidation point.

Another factor contributing to the high number of air shipments to Patillas is that safety stocks are not being used because of the plant's fluctuations in demand. It is their feeling that while safety stocks may be useful in some cases, they may also be extraneous if a particular product is not ordered for long periods of time. If the inventory carrying costs are greater than the cost of having these items air shipped, it will make more sense to send the materials using an economical air carrier with a lead time of two to three days. Safety stocks are only important if the material carrying costs can be shown to be less than the air transportation costs.

Patillas' inventory tracking system, which is called Computer Associate Systems (CAS), is unique when compared with the other Caribe GE plants. This inventory tracking system produces occasional inaccuracies that the current planners at the plant have learned to expect and attempt to compensate for. An example is that the system does not account for the use of material that is on the production floor when it is reporting the material inventory. Patillas will soon be switching to the Manufacturing Execution System (MES) along with the other ten plants in Puerto Rico. MES contains the parameters for billing, manufacturing and purchasing. Lead times, safety stock quantities and production costs are calculated and stored within the system. MES will also enable plant managers to measure the performance of the production lines and determine the level of efficiency at which the plant is operating. Another benefit of MES is that customer orders can be viewed two hours after being placed, as opposed to the 24 hours that the current system requires. Plant personnel will also receive notification two hours after an order is received by a supplier, to ensure that all orders are being received.

The material handling process at this plant begins in the receiving area where personnel enter the materials into the inventory system. The materials are then sent to a stockroom in which materials are divided into the plant sections, DSD or EVC, and taken to two separate warehouses. After a material has been taken from the warehouse, it is not eliminated from the computer tracking system until it goes through production and is sent out through shipping. For this reason there is never an accurate count of available materials. As was discussed earlier the system will report materials as being available even though they have already been set aside for production. This problem of uncontrolled inventory on the production floor is existent in all the Caribe GE manufacturing plants. The problem cannot be eliminated, but measures should be taken to minimize this uncontrolled inventory.

In addition to the computerized tracking method some materials are being stored in a Kanban system. The current process, which utilizes a one-bin method, involves counting material as it is taken and tracked on cards. This causes large amounts of material to be micro-managed. Alternate methods of utilizing these

Kanbans, such as switching to a two-bin method, could be investigated in order to better manage the materials stored in them.

Patillas does not require that air authorizations be completed for all materials that are being flown by air. Only materials that must go by first or second-day air are required to have authorizations filled out. Other materials that are small or have low weights are routinely sent by air. One planner, who brings most of the C class items into the plant, brings them in by air. Authorizations for these items are needed when using next-day air only, since the default is economy air transportation. The plant also receives circuit boards on a routine basis that are shipped to them via air due to the fact that they could be damaged when sent through the consolidation point in Union. Damage could be prevented by improving the packaging that the boards are being shipped in, thus allowing them to be transported via ocean.

In an effort to reduce the frequency of air shipments from several suppliers, the plant recently began to have small items consolidated into one package. Further steps can still be taken to reduce the air transportation costs that Patillas is experiencing. Continuing to encourage their suppliers to consolidate these small packages is important, but the plant could also have these consolidated items sent through Union and to Puerto Rico via ocean. This procedure would be desirable whenever the cost of carrying the additional inventory in transit was less than the savings in air transport cost.

Suppliers can also be contacted in order to verify that they are utilizing the desired carrier, or method of transportation, as a default. Increased communication with a supplier will benefit both the supplier and the plant. By keeping their suppliers knowledgeable about their desired processes, the Patillas plant will develop a beneficial relationship that could result in opportunities such as successful consignments, or better compliance with plant requests.

Arecibo

GE Arecibo spent the second highest amount on air transportation in 1999, second only to Patillas. The plant produces electro-mechanical circuit breakers for industrial applications. Customers place orders for these products through the GE office in Bloomington, North Carolina, and these orders are then sent to the Arecibo Plant. There is also a weekly teleconference where any required changes are made. Eighty percent of GE Arecibo's output is sent to a warehouse in Mascot, Tennessee where customers purchase items in a similar manner to a supermarket. The other 20 percent comes in the form of specialized customer orders that are sent directly to the customer once they are completed. Arecibo is the first in sales out of the 10 GE plants on the Island of Puerto Rico, selling approximately 130 million dollars worth of products last year.

Arecibo can forecast production demand six weeks ahead of their current production. In doing this they look at the customer orders for the past year. GE Arecibo has four purchase planners, also know as Planners, who are responsible for procuring raw materials and components that will be used in production. Currently they are divided into both product line and materials being ordered. In the next few months however, they are planning on implementing MES and dividing the planners up by materials ordered only. This new division should help to eliminate multiple shipments being sent from a single supplier in one day. If the planners have increased knowledge about what parts need to be ordered from a supplier, they can hold off on placing orders or request that orders are consolidated at the supplier before they are shipped.

Consignment is utilized at the Arecibo plant with the intent of lowering transportation costs and reducing the frequency of exhaustion of materials. When more raw materials are needed, it is the responsibility of the supplier to ensure that the raw materials arrive in time for production, to avoid production stops. If the supplier is unable to deliver the materials on time and they have to be expedited by air, the supplier is responsible for paying for these costs. The current process for charging the suppliers for air transportation involves the plant paying the charges and receiving a credit to their account. Unfortunately, it is difficult to charge the supplier for these transportation costs because of the way the ordering system is designed. Presently, there is no method by which to determine whether an expedited shipment is the fault of the supplier. The billing personnel in Fort Meyers, Florida, generate a monthly report and with the high frequency of air shipments, it would be a tedious process to investigate each air shipment in order to determine the cause for it. A tracking system is needed to keep a record of which shipments should be charged to the supplier, at the time the shipment is ordered rather than at the end of the month. If it cannot be determined from the report which shipments should be charged to the supplier, it is impossible to receive a credit for the charges.

The Materials Manager also stated that the plant has been having problems with being unknowingly billed for invoices for materials that were ordered by and sent to a different plant in Puerto Rico. It was explained to us that each plant should have its own account with the suppliers but that suppliers will frequently see the name GE and randomly select the account number to which shipments will be billed.

Due to the transition to only one shipment per week leaving Union, it is necessary to forecast the need for materials even farther in advance. This has had a great impact on the materials ordering process here. In order to compensate for this, new lead times are currently being worked out that will assist in meeting the Thursday deadline for having materials at the consolidation point.

The typical reason for air transportation is customers placing special orders and not allowing enough lead-time for materials to be sent to the plant. In addition, the plant also has electronic boards normally sent by air. The reason for this is that the boards are delicate and could be damaged when sent by ocean freight. The boards are ordered in lot sizes worth approximately $97,000, and are usually shipped using Emery second-day air. Utilizing Caribbean Air services when they are available in the area of the supplier could reduce the transportation costs to the plant. Currently a consignment deal is also being made with the supplier of these electronic boards in an effort to lower these air transportation costs. As stated earlier, packaging of the electronic boards might also be improved such that it would no longer be necessary to send them via air transport.

Currently at Arecibo, an air authorization is required only if the material being shipped is more than 25 pounds. The electronic boards that the plant is using in production also do not have to be air authorized. As a part of the control measures regarding air authorizations a system will need to be implemented to ensure that all shipments are authorized unless specified in company protocol. Currently, silver powder is the only material that should be sent by air as a default and there needs to be a way of verifying that no other materials are being shipped in this manner.

Another procedure observed in the Arecibo plant was the use of blanket orders. A blanket order is a contract between a company and a supplier guaranteeing the purchase of a quantity of material over a given period of time, in this case three months. There are two benefits to this system which should, in theory, reduce the necessity for expedited shipping. The first is that lead-time will be decreased, because the raw material will already be on hand at the supplier's warehouse. Second, one purchase order can be used for the entire three months, which saves time. One drawback to this system is that when an order is expedited it is given the same purchase order as several other orders and thus it becomes difficult to determine when expedited shipments are the fault of the supplier.

The A,B,C classification data was also given to us on our visit to Arecibo. A items are shipped every two weeks while B and C items are shipped every 6 to 10 weeks. Once the plant receives the material, it is brought to the stockroom and an inventory count is taken. The plant's safety stock process was also explained to us. In calculating safety stock quantities lead time is not taken into account but projected demand is included as a factor. We were told that they frequently find themselves running out of stock and stated that for problem parts they have eight days worth of safety stock. Safety stocks will be established for all products based upon the calculations of the Crystal Ball software explained earlier. In addition, Arecibo is currently resizing their Kanbans in an effort to reduce the number of air shipments resulting from depletion of stock.

Vega Baja

The Vega Baja plant produces a variety of large industrial circuit breakers. The production schedule at this plant is currently being forecast using a Mapics system, which all ten plants will eventually convert to. The system's capabilities are being used to generate a production schedule on a weekly basis. By considering weekly usage, quantity on hand, and lead time, the system calculates the need for each material used in the plant. Planners generate material orders through Mapics and enter the orders into the Oracle system. The system utilizes (EDI) and automatically sends a fax or e-mail to the supplier notifying them of a material order. One problem that was noted, was the occurrence of material orders not reaching the supplier because of an error in the Oracle system. As was stated earlier, GE manufacturing plants worldwide will be implementing the Manufacturing Execution System. This system allows the plant to check online, two hours after the order has been placed, to see whether or not the supplier has received an order for a material.

When materials arrive at the plant they are entered into the inventory system and sent to the stockroom. Planners notify personnel in receiving when a material is needed on the production floor, and the materials are then moved from the stockroom to the floor and deleted immediately from the available inventory. This method of tracking causes materials on the production floor to not be accounted for in the system, making the planners unaware of the real material inventory. This is the same problem that Patillas has with uncontrolled inventory.

In addition to the computerized tracking system, Kanbans are being used and are currently in the process of being resized to more accurately meet production needs. The desired amount of stocks at the re-order point is two weeks worth and a "smart lot-sizing" calculation is being done to correctly determine both the Kanban and lot sizes. Line managers are in charge of notifying the planners when materials are needed from the stockroom to replenish the Kanbans and the planners then alert the personnel in receiving. Personnel in receiving remove the necessary number of bins from the stockroom and bring them to the production floor. Materials for production are taken directly from the Kanbans on the production floor. The empty Kanbans are returned to the stockroom and when the established number of empty bins has accumulated, the receiving personnel notify the planners of the need to place an order.

The Vega Baja plant is not currently using safety stocks, which is contributing to their need for expedited shipments of materials. They have established a two-week re-order point for A items and three weeks for B and C items. However, these quantities are not sufficient to cover lead times from suppliers. The Crystal Ball program discussed earlier will assist in the implementation of safety stocks at the plant, which should help prevent the need to expedite materials.

The re-order quantity is also based upon the assumption that there are three days worth of A items in stock and one week of B and C items in stock on the production floor at the time the order is placed. These amounts may be altered when MES is implemented at the plant.

A unique air authorization procedure is being followed at the Vega Baja Plant. Packages that weigh less than twenty pounds do not need authorization for expedited shipping. This is similar to the policies that are being carried out at the Arecibo Plant. The number of these shipments that are less than twenty pounds can reach high levels when not controlled, due to multiple materials planners ordering these parts.

Another procedure being followed here is to track the air shipments that occur due to suppliers not complying with the agreed upon lead-time. When the supplier is at fault for expedited shipping a form is filled out by the planner. The form is then sent to the receiving area and personnel there further fill out the information when the materials are actually received. A log is then kept for the month and personnel in finance bill the suppliers for the shipping charges. This process is new in Vega Baja and it will be necessary to wait a couple of months to determine how effectively the system is actually working. This procedure is being followed due to the high air transportation costs resulting from suppliers in consignment with them. According to the rules of consignment, Vega Baja should never have to pay for air transportation costs.

Consignment is being used fairly heavily at the Vega Baja plant and in theory should cut down on the usage of expedited shipping. The suppliers are responsible for sending materials based on the weekly usage reported by the planners. At Vega Baja, the suppliers who use expedited shipping the most are the ones who are under consignment. This situation is in part due to the failure of the Vega Baja Plant to give the supplier under consignment an acceptable forecast of their materials usage. Because of this, the supplier does not know when it should send materials to the plant to replenish its supply.

Vega Alta Controls

The Controls plant is one of two plants located in Vega Alta. It produces a wide variety of electronic controls, along with some molding of plastics that are used internally by Caribe GE. The plant's production schedule is forecasted by a Distribution Requirements Planning system originating from a GE facility in Bloomington, NC. The information is sent to the Controls plant through the MES system that is currently in place there and is used by the buyers in their ordering processes. Many of the plants' products are highly customized. Planners have difficulty successfully forecasting the need for some materials that are only used on customized parts. The plant experiences fluctuations in demand by season because some of its customers are located in the northern United States.

The Vega Alta Controls plant is not extensively utilizing safety stocks due to the variability in demand for some materials. Information regarding safety stocks that are being kept appears in the section of the MES system known as Time Phase. Within this Time Phase section, information is available about not only safety stocks, but also lead times and A,B,C, values for materials. As stated earlier, the optimal safety stock quantities for all ten plants will be determined with the implementation of the Crystal Ball program. These calculations should help to reduce the number of air shipments despite the fluctuations in demand experienced by Vega Alta.

Materials at this plant are kept in three different warehouses. Some materials are kept in Kanbans, where they are tracked using a two-bin system. An adequate number of Kanbans are kept on the floor for production, while the remainder is kept in a secured area on the production floor with restricted access. This division is to ensure that materials are correctly tracked throughout the material handling process. Visibility of materials is lost when they are removed from the secured area and placed on the floor because they are deleted from the inventory tracking system at this time. For this reason, it is difficult to determine at what point the materials in the Kanbans on the production floor will need replenishment without projecting and tracking the weekly usages. It is important to have record of the average usage of all materials so that the re-order point is not missed requiring material orders to be placed with insufficient lead-time.

Vega Alta is currently using consignment with two of its major suppliers; Capital Metals and Omnimetal. These consignments began in February of this year and a third is currently being negotiated with another major supplier. All consignment materials are kept in a secured warehouse with limited access, which is in the process of being expanded. The consignment system is not operating the way that it is intended to in the Vega Alta plant. The suppliers who are most frequently expediting materials to the plant are those who have consignment deals established. In order to eliminate this occurrence there needs to be increased communication between the plant and the supplier. According to personnel in the Sourcing Office, several suppliers have complained that they are not being given adequate forecasts of the plants' material needs. In order for the consignment process to operate effectively, average usages as well as accurate reports of usage must continuously be relayed to the supplier to avoid unexpected shortages of materials.

Some materials at this plant are sent by air as a default because of their fragility or value. These materials are not required to have air transportation authorizations filled out for them. All other materials that are expedited by air are required to have a completed authorization form. Expedited shipping is done through the Bayamon Sourcing Office and the buyers there are responsible for stipulating the proper carrier. Again, there needs to be controls in place to prevent the routine expediting of materials that have not received exceptions from the Bayamon Sourcing personnel.

Synopsis of Results

Consignment

Consignment is currently being developed with many suppliers for the Puerto Rican GE plants. These agreements with the suppliers can prove to be very beneficial because the plant no longer needs to manage the inventory of the materials. It becomes the responsibility of the supplier under consignment to track the level of materials that are left in storage at the consignment site and to replenish this inventory whenever necessary. Earlier, we had discussed that these consignment agreements are not always working out properly because the suppliers are transporting their materials via air, and then charging the manufacturing plant for the transportation. In order to correct this situation we are proposing two procedures, that will have the most success if used in conjunction with one another.

When speaking with the Materials Manager at the Vega Baja plant, we learned of a system that they recently began using in order to charge-back suppliers under consignment that should be paying for air transportation. When ordering any air shipment whose cost should be charged to a consignment supplier, the planner must fill out a form that details the material including weight, value and reason for the air shipment. This form is then passed onto the receiving area, and when the material is received the remainder of the form is filled out and passed on to the Materials Manager. The Materials Manager reviews the form and sends it to the Finance Department, which contacts the supplier in order to correct the billing. This procedure could be applied to each plant, and facilitate the process of charging suppliers for air shipments when they fail to meet material needs. By making the supplier aware that the billing is being tracked they may also be less likely to send the materials by air.

Another possible reason for the supplier billing the plant for the transportation is because of the plant's lack of cooperation with the supplier. In order to determine correctly when to restock the inventory for a consignment material, the supplier must be able to forecast the plant's demand for this material. This cannot be done without the supplier having information from the plant about the plant's forecast for production. By maintaining contact with suppliers that are under consignment with them, the plant should be able to keep the supplier informed about material needs. Conversely the supplier will be able to keep the plant aware of any problems they might have in meeting these needs. By utilizing these suggestions, many of the problems that are currently being experienced with suppliers under consignment can be corrected, and both parties can benefit from the arrangement. Due to the volatility of demand for some products there are materials whose need is difficult to forecast. In this case it is difficult to determine whether it is the fault of the supplier under consignment or if it is just the nature of the uncertainty in demand that causes items to be transported using next day air. Unless GE is able to prove that it is the fault of the supplier, the supplier cannot be held responsible for the use of next day shipping. The inventory of materials that have a high uncertainty of demand should be assessed on a regular basis in order to determine whether it would be worthwhile to increase inventory levels instead of transporting these materials by air.

When assessing the current inventory levels of items that have a high uncertainty of demand two things need to be taken into consideration. First is the past usage. By looking at past usage over the period on no less than a year, patterns for usage can be determined as well as average usage per month. These help to determine how much of an item will be needed and when. In addition, current uncertainty in demand can be determined, which is important in determining the size of inventory levels for different parts. Secondly, the number of air shipments made per item for each month can be examined. Causes can be determined for these air shipments and then corrections can be made to prevent their use. The key preventative measure is believed to be an increase in inventory.

Lead Time

For a supplier to have a shipment arrive at a Caribe GE plant via the predetermined ocean route, enough time must be accounted for to transport the material from the supplier to the consolidation point, from the consolidation point to San Juan, and from San Juan to the manufacturing plant. These times are all constant except for the time from the supplier to the consolidation point, which will vary depending upon the location of the supplier's facility. Also, since only one shipment departs from the consolidation point in Union, NJ per week, the material may be in storage at the consolidation point for some time depending on when it arrives.

Without knowing the correct lead times the planners cannot know when the material should be reordered. Our suggestion is that any plant that is having trouble with particular suppliers should review the lead time that they have on record for the supplier, and verify this with them. With this information, the reorder points for these suppliers can be adjusted to allow sufficient time for ocean transport.

Kanbans

Various plants that we visited were using Kanban systems to manage a portion of their inventory. In general these Kanbans were located on the production floor which is known as an uncontrolled area. An uncontrolled area is any area where the current level of inventory is uncertain. It is desirable to minimize the number of uncontrolled areas within a plant. At most of the GE plants we visited, the production floor was a completely uncontrolled area, however at some plants there were a few secure areas on the production floor. This was because only authorized people were given access to these secure areas and these same people were given the responsibility of tracking it. By placing as many of these Kanbans as possible into controlled areas, it will be create a more accurate method of determining inventory levels.

We also encountered various methods of tracking the material using Kanbans. Some plants used a two-bin method where an entire Kanban will be emptied and later replaced with another full Kanban. Other plants use a micromanagement process where they track, on cards, how much material has been taken out of a single Kanban and later replenish the material in this Kanban. Switching to a two-bin system would be advantageous in this case because it would avoid the process of micromanaging the material, and make the inventory tracking process more efficient.

Air Shipment Defaults

In speaking with personnel at the ten plants we became aware that purchase planners at each plant are following procedures different from those established by GE. In many cases air shipments under a specified weight, typically twenty or twenty-five pounds, are not receiving authorization from the materials or plant managers. This usage of air services without authorization is a great contributor to high transportation costs. In order to eliminate this additional cost we suggest that defaults for air shipments be examined at each of the plants. It is necessary to determine the exact procedures being followed and ensure that all personnel are aware of the company protocol regarding air transportation. A standard practice must be developed with detailed instructions for planners to follow when placing orders.

Our analysis of company protocol pertaining to air shipments led us to the conclusion that revisions are necessary in order to reduce transportation costs. Currently planners should be following the guidelines issued by the transportation leader in the Bayamon Sourcing office. This document is included as Appendix C. The document states that all next day shipments under 150 pounds should be sent by Fed Ex. However, Fed Ex next-day air rates become more expensive than Emery's after nineteen pounds. The document also stipulates Fed Ex as the carrier for second-day services for material under 150 pounds, despite the fact that Emery's services are cheaper for materials over twenty pounds. GE has established deals with Eagle Global Logisitics and Carribean Transportation Services as well. These carriers are both cheaper than Fed Ex or Emery and all air shipments should ideally be sent through them. Due to the location of both carriers hubs as well as the limited services they offer from some areas of the United States, it is often necessary to utilize Fed Ex or Emery's services. We recommend that a detailed procedure be drawn up stipulating which carrier should be used for specified weight ranges depending upon the location of the supplier. The document should be issued to all requestors to ensure that they are aware of what services are available in specific areas and which methods are the cheapest for the service they require.

Ordering Procedures

In addition to examining the procedures being followed at each plant, it is necessary to examine the procedures being followed by each supplier when determining what services should be utilized for shipping materials. Several planners alerted us to the fact that suppliers are often making the decision about how materials should be shipped. An example of a supplier using an inappropriate default setting is the GE plant in Salem, Virginia, which sends components to Patillas. Their default setting is next-day air for all shipments. If this is changed to an alternate method of transportation, preferably ocean transport, there will be an increase in savings.

One reason for suppliers sending materials via next-day air is that when the planners place an order they do not always complete the "ship via" field in the Oracle ordering system. Without the data in this field it is up to the supplier to determine how the materials should be shipped. In order to eliminate this problem, the system needs to be altered such that orders cannot be placed unless the requestor specifies how the materials should be sent and which carrier should be used for air shipments. Once the field has been made mandatory, it will also be necessary to ensure that suppliers comply with the stipulations of the requestors. To ensure that this happens all air shipments should be validated to determine who made the decision that the materials should be sent via air transport.

To decrease the number of shipments being sent by air due to suppliers making the decision, communications between plants and suppliers should be increased. The suppliers who are frequently sending materials via air should be contacted and informed of the desired carrier for different weights of materials. This information, along with the information given in the ship via field regarding whether next-day, second-day or ocean shipping should be used will hopefully eliminate air shipments that are unnecessary and have not been requested by the planners.

Human Interaction Issues

The societal portion of our Interactive Qualifying Project (IQP) dealt with human resources and people's reactions to proposed changes. On each of the plant tours we made the decision to identify ourselves as students, which may have impacted the responses that we received from our questions. The manner in which we explained the purpose of our visits was also important to the results obtained. We were careful to specify that our visit was to observe the procedures at each plant and develop a best practices procedure from all the processes we observed. It was our hope that in phrasing the goal this way we might discover the possible faults in their processes without causing an unwillingness to speak to us.

Another social impact will be the reactions of personnel to the final recommendations. Several planners have been with GE for many years and may be resistive to changing the procedures they are used to following. In most cases it seemed that the planners were simply unaware of the established protocol for air shipments. When we were told that all shipments under twenty pounds did not need authorization, the planners shared with us their rationale for sending these shipments by air. There is a feeling that small packages will be lost or damaged if sent via the ocean route and thus it has been approved at the plant level that these smaller shipments do not need authorization. If the suppliers follow through with the proposal of consolidating shipments, as mentioned above, hopefully many of these smaller shipments can be sent together through the consolidation point in Union, NJ. In general it seemed that there was lack of awareness of the impact of sending such a high frequency of air shipments, even for small packages. It did seem however, that the personnel responsible for placing orders would for the most part be willing to adopt new procedures if they were simply told what those procedures are. Currently, there is not a clear policy that has been made known to all planners and this is the root of the problem.

The presentation of the findings and recommendations will also be important to how well the information is received by plant personnel. Our liaison has requested that we create best practices hand outs for both the managers and the requestors at each plant. In creating these documents it will be our goal to be understanding about how things have been done in the past, and clear about how they should be done in the future. In order to obtain compliance from personnel in following the new procedures we will present them with supporting data contained in our report to demonstrate how much money could be saved if practices were improved.

In the past General Electric has pushed the idea of keeping inventory levels low to reduce costs. Personnel at the plants are now working with this mindset and in order for changes to be implemented we must successfully change this mindset. Increased awareness about the relative costs of holding materials and flying them by air must be demonstrated to personnel in order to prove that holding inventory is still cheaper than transporting materials by air.

Advantages of Ocean Transportation

We found that Caribe GE will save substantial amounts of money by increasing inventory and decreasing the usage of air transportation services. In order to prove that increasing inventory levels and transporting by ocean is more cost effective than using air transportation and carrying less inventory we created a simple model to compare the two. GE calculates their annual inventory carrying cost to be ten percent of the material value. In order to calculate the inventory carrying costs per day we divided the ten percent annual rate by 365 days, and used this number in our calculations. The following example calculation is taken from an actual invoice for materials shipped by air.

Forty-seven stamped parts were sent from Carolina Stampings in North Carolina to the GE plant in Patillas. The total weight of the parts was three pounds and their total value was $375.53. If these materials were sent by Emery 2nd day air it would cost $25.00, taken from air rates provided in Appendix E, to ship them. The two day inventory carrying cost for these materials was $0.21. Therefore, the total cost for second-day air was $25.21. Had the parts been shipped by ocean freighter the transportation cost would be $0.05 per pound, or $0.15 total. The $0.05 per pound figure is the average cost of shipping materials through GE's consolidation point in Union, NJ according to our liaison, James Kinney. This includes ground transportation from the supplier to Union, ocean freight from Union to San Juan and inter-island transport from San Juan to the specific plants. The inventory carrying cost associated with ocean transport for this case would be for ten days, the average number of days required for ocean transport, and would cost $1.03. The total cost for ocean transportation would be $1.18, giving a 95.4 percent savings over the cost of the air transportation.

Cost calculations were based upon the use of the carrier with the least expensive transportation cost for a specific weight. We found that for the use of next-day air, Federal Express should be used for materials under twenty pounds and Emery for those twenty pounds and over. For second-day air or economy air transportation, Fed Ex economy rates should be used for materials under twenty-one pounds and Emery second-day for material twenty-one pounds and over. After twenty pounds, Emery's second-day services become cheaper than Fed Ex's economy service, thus all materials over twenty pounds being shipped by air should be sent either next or second-day air. Any materials over 150 pounds should be sent using Caribbean Transportation Services or Eagle Global Logistics. Ocean transportation was based upon an average of five cents per pound for all ground and ocean transportation, and an average inventory holding time of ten days, as was explained earlier.

To support our recommendation that increasing inventory levels is cheaper than utilizing air shipment services, various graphs were created to compare the associated costs of both. The Y-axis of each graph represents the item's value in dollars and the X-axis of each graph represents the item's weight in pounds. On each graph there are seven lines, each representing the period of time that an item would be carried in inventory. The first line begins at two weeks and an additional week is added to each subsequent line, up to eight weeks. The line for a one-week inventory holding period was not calculated because our recommendation is to utilize the ocean transportation route which requires an average of ten days. Eight weeks was chosen as the last line for this graph because according to our liaison this is the maximum period of time most frequently used materials would be held. The line for each period of time represents the point at which the inventory carrying costs equal the sum of the transportation costs and in transit inventory costs. This means that if an item were to fall on this line a requestor could either carry this item in inventory for the specified amount of time or ship it using the premium air service specified by the graph, because the costs are equal. If the item were to fall above the line it would be cheaper to ship using the same premium air, and if an item were to fall below the line it would be cheaper to carry in inventory.

In order to create the lines for our graphs, we used two equations. These two equations are the inventory carrying cost equation and the transportation cost plus inventory in transit carrying cost equation. A few assumptions were made in calculating these costs.

Assumptions

1. A month is 30 days in length.
2. There are 365 days in a year.
3. The value and weight of the item that is to be kept in inventory is the same as the value and weight of the item to be shipped using air transport.
4. The annual inventory carrying cost is 10 percent of the value of this item. In order to calculate the daily inventory carrying cost for an item we

divide the 10 percent by 365 days and then multiply the result by the value of the item.

Inventory Carrying Cost Equation

I_c is the inventory carrying cost

V is the value of the material

t_1 is the number of days the material is kept in inventory at the plant

The equation for inventory carrying cost is:

$$I_c = \left(\frac{0.10}{365}\right) \cdot V \cdot t_1 = 0.000274 \cdot V \cdot t_1$$

where $\left(\frac{0.10}{365}\right) \cdot V \cdot t_1$ is the ten percent annual inventory carrying cost, divided by the number of days in a year. This expression is then multiplied by the value, V, of the material and the number of days the item will be held in inventory, denoted as t_1.

Transportation Cost with Inventory in Transit Costs Included

C_A is the transportation plus in transit inventory carrying cost

t_2 is the number of days the material is in transit

T_C (w) is the transportation rate as a function of weight in pounds. Depending upon the type of transportation used, the cost will be different for each weight shipped.

The equation for transportation cost with inventory in transit costs included is:

$$C_A = \left(\frac{0.10}{365}\right) \cdot V \cdot t_2 + T_C(w)$$

For each line, t_1 is predetermined by the length of time the item will be carried in inventory. t_2 and T_c (w) are dependent upon the type of transportation used. In the case of next-day air, t_2 is equal to 1. For each weight, from 1 to 150 pounds, a value V needs to be found where I_c is equal to C_A . V is found by solving the following equations.

$I_c = C_A$

$$\left(\frac{0.10}{365}\right) \cdot V \cdot t_1 = \left(\frac{0.10}{365}\right) \cdot V \cdot t_2 + T_c(w)$$

further simplification yields:

$$0.000274 \cdot V \cdot t_1 = 0.000274 \cdot V \cdot t_2 + T_C(w)$$

solving for V, we obtain:

$$V = \frac{T_C(w)}{0.000274\ (t_1 - t_2)}$$

This is the equation that gives us our line, as defined earlier. By entering this into an excel sheet, along with the corresponding weights and costs, we were able to determine the lines used in our graphs. Each point on a line is defined by a specific weight and material value. When a weight and value combination is above the line representing the specified time period for inventory carrying, including the time in transit, it is more economical to utilize the air shipping method defined by the graph. If the weight and value combination is below the line then inventory should be increased. For example the two-week line in **Figure 5-1** shows that a ten pound shipment would have to be worth over $4000 dollars before it would be more economical to send it by air rather than hold it in inventory.

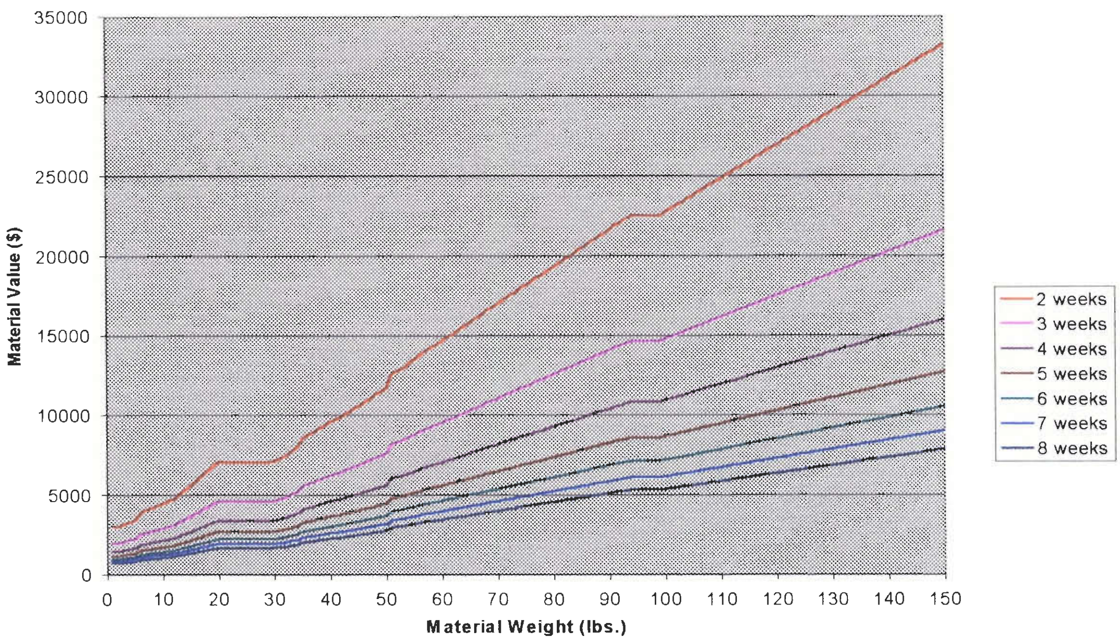

Figure 5-1 Inventory Carrying Costs for Two to Eight Weeks vs. Next-Day Air Transportation Costs for Materials Under 150 pounds

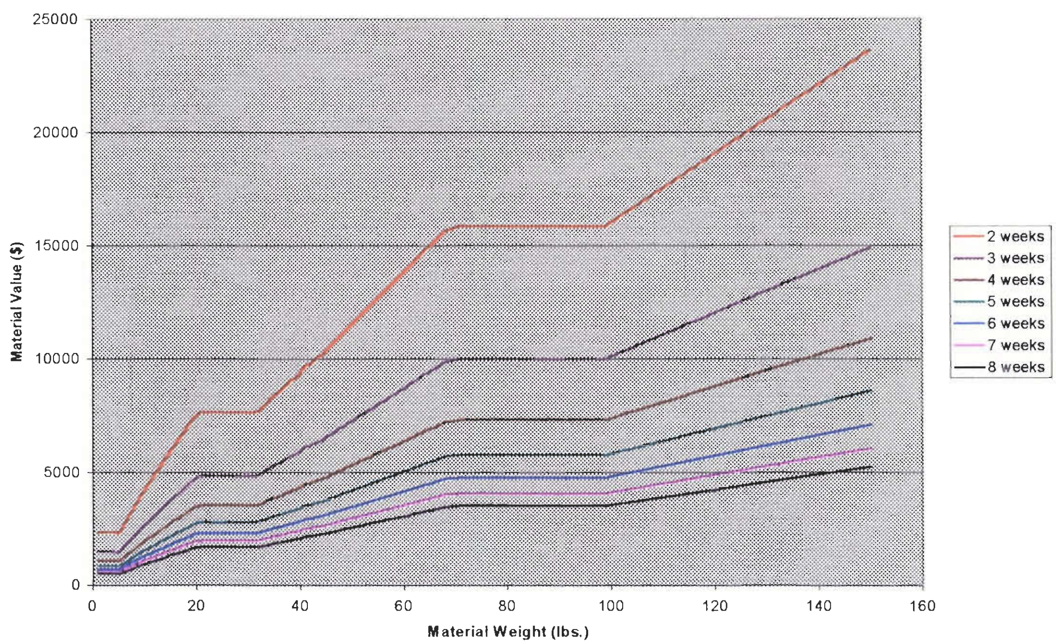

Figure 5-2 Inventory Carrying Costs for Two to Eight Weeks vs. Second-Day Air Transportation Costs for Materials Under 150 pounds

The calculated lines previously discussed for both next-day air and second-day air transportation, for materials under 150 pounds, are given in **Figures 5-1** and **5-2.** Each graph displays the lines calculated for various inventory carrying times ranging from two to eight weeks. The corresponding graphs for materials over 150 pounds are given in **Figures 5-3** and **5-4**.

In order to further illustrate the importance of figures such as the one shown below, an example is provided.

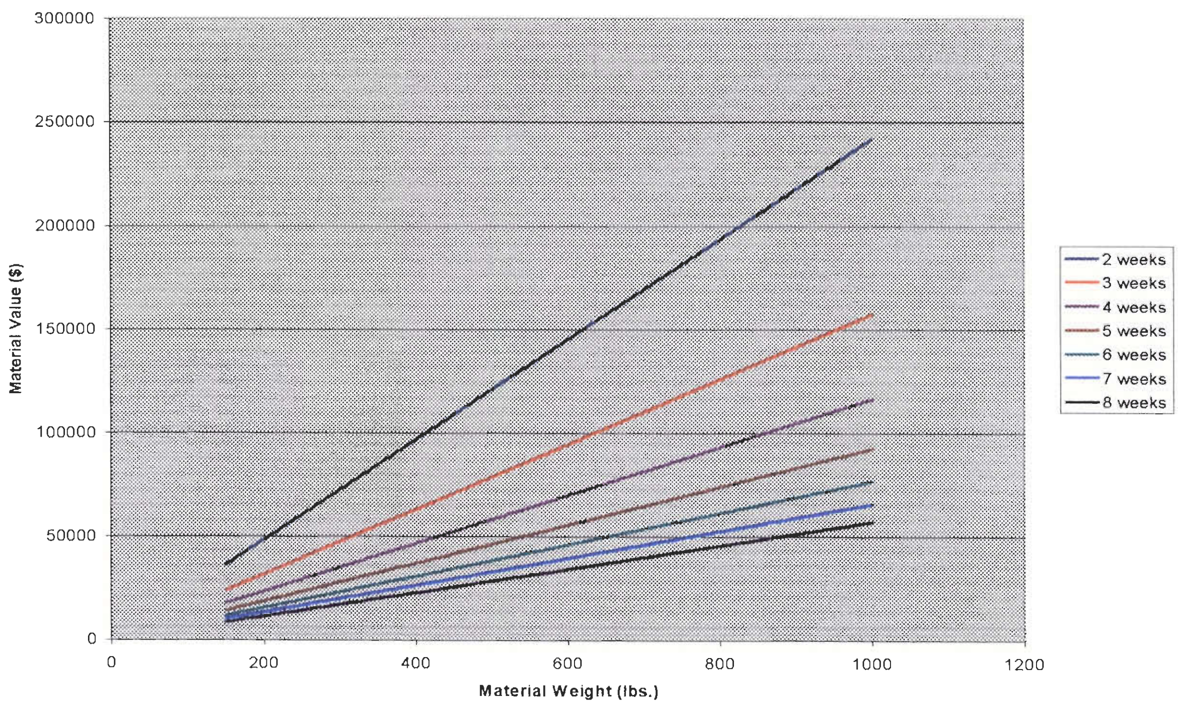

Figure 5-3 Inventory Carrying Costs for Two to Eight Weeks vs. Next-Day Air Transportation Costs for Materials Over 150 Pounds

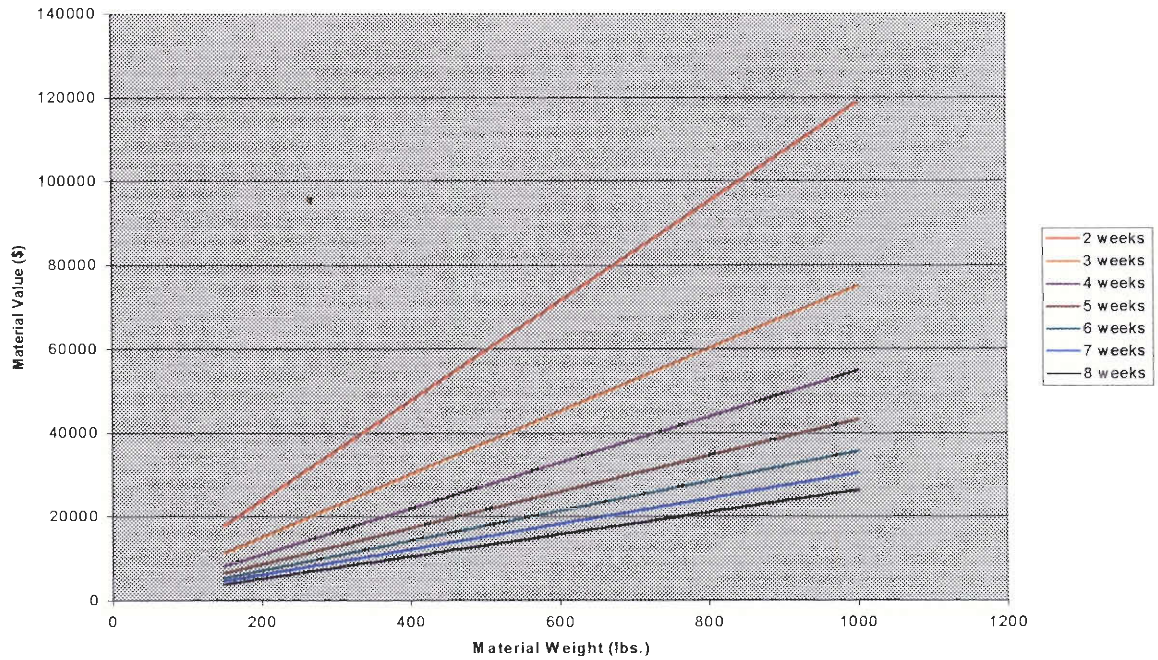

Figure 5-4 Inventory Carrying Costs for Two to Eight Weeks vs. Second-Day Air Transportation Costs for Materials Over 150 Pounds

Example

Several items are used in production every two months. A planner wants to know whether it would be cheaper to keep them in inventory for the two months or fly them in using next-day air when they are needed for production. All of these items vary greatly in weight and value.

We know that these items will be kept in inventory for two months, which is equal to 60 days based on our assumptions. Therefore $\mathbf{t_1 = 60}$ **days.** We also know that next-day air will be used therefore $\mathbf{t_2 = 1}$ **day.** In order to obtain data for $\mathbf{T_C\ (w)}$ we will use the rates for next-day air, which can be found in Appendix E.

In order to create the actual graph, we will use a Microsoft Excel spreadsheet, a portion of which is shown in **Table 5-1** for 1 to 20 pounds. In **column A** of the original spreadsheet, we listed all pounds from 1 to 150 in 1 pound increments. In **column B** we gave the cost of next-day air for each pound 1 to 150. Finally, in **column C** we used our equation for V, the value required to make the inventory carrying costs equal the next-day air shipping costs with inventory in transit considered.

Using the values given our equation for V is.

$$V = \frac{T_C(w)}{0.000274(60-1)}$$

Where T_C (w) will be different for each pound and dependent upon the air rates given to us by our liaison. We will then use a scatter plot to display our results.

lbs	Next-Day Air	2 months
1	$10.65	$670.15
2	$10.65	$670.15
3	$11.15	$701.61
4	$11.65	$733.07
5	$12.15	$764.54
6	$13.74	$864.59
7	$14.26	$897.31
8	$14.78	$930.03
9	$15.30	$962.75
10	$15.82	$995.47
11	$16.34	$1,028.19
12	$16.86	$1,060.91
13	$17.90	$1,126.35
14	$18.94	$1,191.79
15	$19.98	$1,257.24
16	$21.02	$1,322.68
17	$22.06	$1,388.12
18	$23.10	$1,453.56
19	$24.14	$1,519.00
20	$25.00	$1,573.12

Table 5-1 Calculation of the Value at Which Inventory Carrying Costs Equal Next-Day Air Shipping Costs

Column B will be on the X-axis and column C will be on the Y-axis. **Figure 5-5** shows the graph created using these parameters.

The requestor will now be able to use the item's value and weight to determine whether or not to keep the item in inventory for 60 days. As was stated earlier, if the item falls on the line it can either be shipped using next-day air or kept in inventory for 60 days because the costs would be equal. If the item's cost and weight cause it to fall above the line it would be cheaper for it to be sent using next-day air than to keep it in inventory for the 60 days. Finally, if the item's weight and value caused it to fall below the line it would be cheaper for it to be kept in inventory for the 60 days.

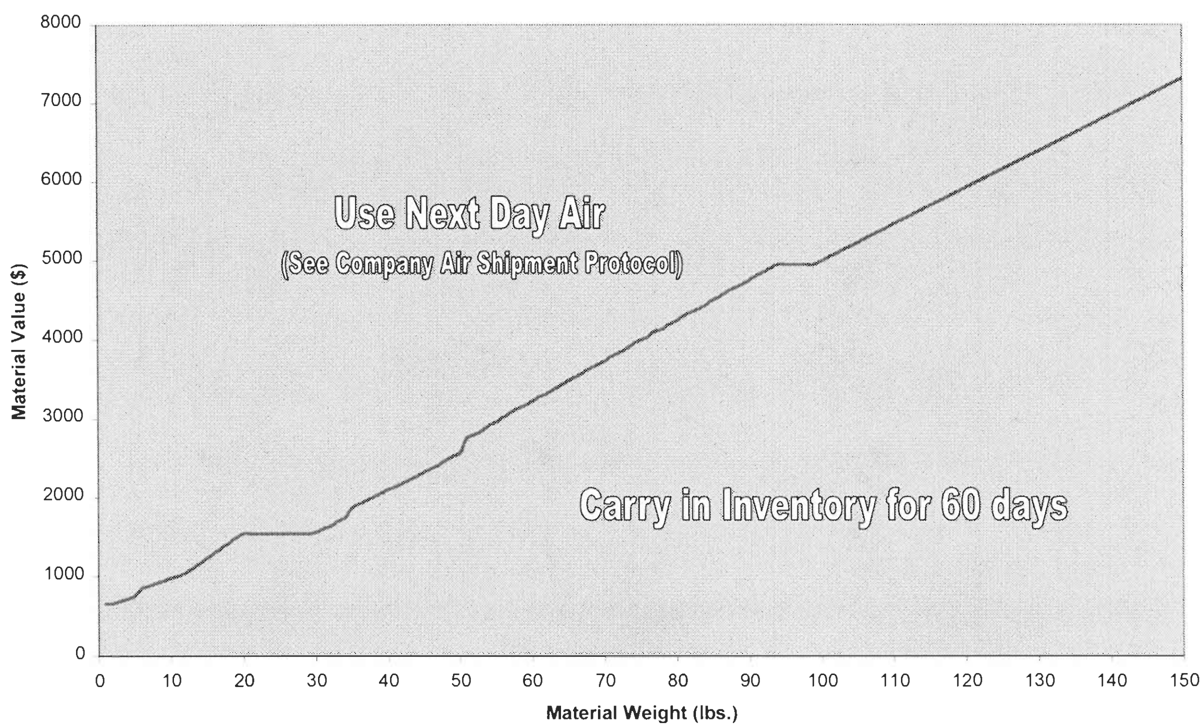

Figure 5-5 Comparison of Keeping Two Months of Inventory vs. Transporting Next-Day Air

This sample graph displays the fact that in order to justify sending materials by air, even for long periods of carrying inventory, the material's value must be substantially high with respect to its weight. It is expected that the use of these charts will facilitate the decision making process for the requestor as well as reinforce the point that in many cases, it is more cost effective to carry an inventory than it is to send materials using either next-day or second-day air services.

Air Transportation versus Carrying Infrequently Used Parts

During our plant interviews, several planners told us that the uncertainty in demand for certain items forces them to bring materials in using either next-day or second-day air services. The planners feel that it is more cost effective to bring these materials in using next-day or second-day air than to carry these items in inventory for an extended period of time, sometimes as long as a year. In most cases this is a misconception that needs to be addressed. In an effort to do so, a group of graphs have been created to show the planners when it is more cost effective to ship by next-day air and when it is cheaper to carry a particular item in inventory for the amount of time it will not be used in production.

To counter the argument that air shipping is more economical than carrying inventory for extended periods of time, **Figures 5-6** and **5-7** were created. These figures display the material values and corresponding weights necessary to justify air shipping. As depicted by the graphs, materials must still have a relatively high value compared with their weight in order for inventory carrying costs to exceed the costs of expedited air shipping. Even for a period of an entire year, 150 pounds of material would have to be worth over $1000 dollars to justify expedited air shipping. Though this value of material may be plausible, this is an extreme case and most materials would not need to be held for this length of time. Most infrequently used materials will only need to be held in inventory for a period of two to six months. The material values needed in order to validate air shipping for these time periods are more than two to six times that of the previous yearly example.

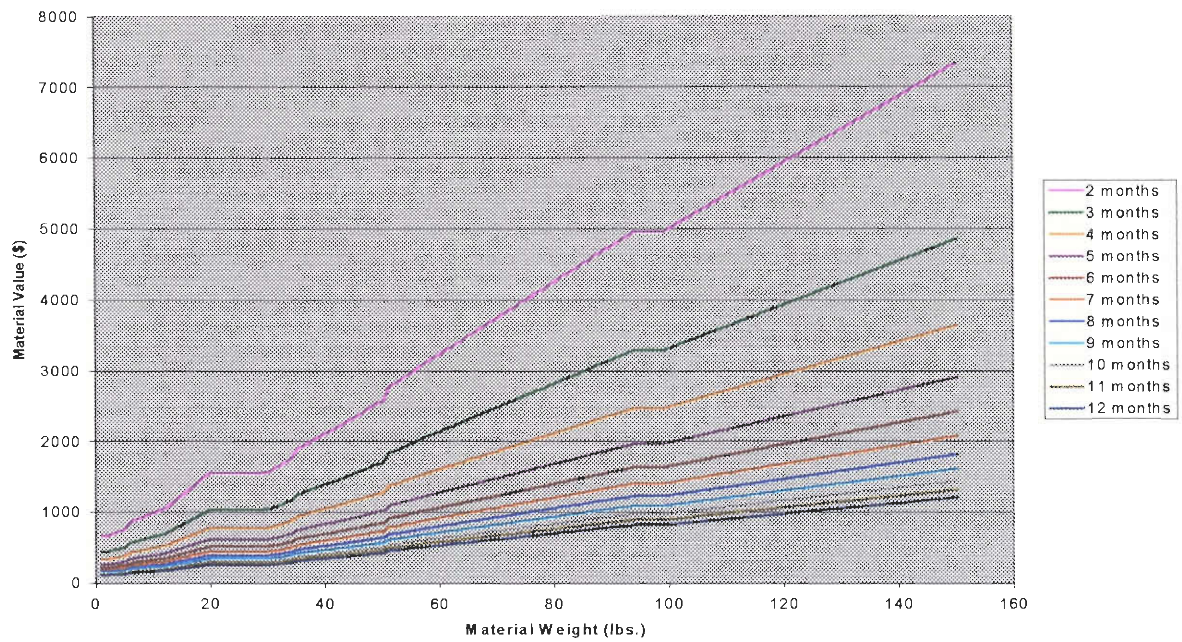

Figure 5-6 Inventory Carrying Costs for Two to Twelve Months vs. Next-Day Air Transportation Costs for Materials Under 150 pounds

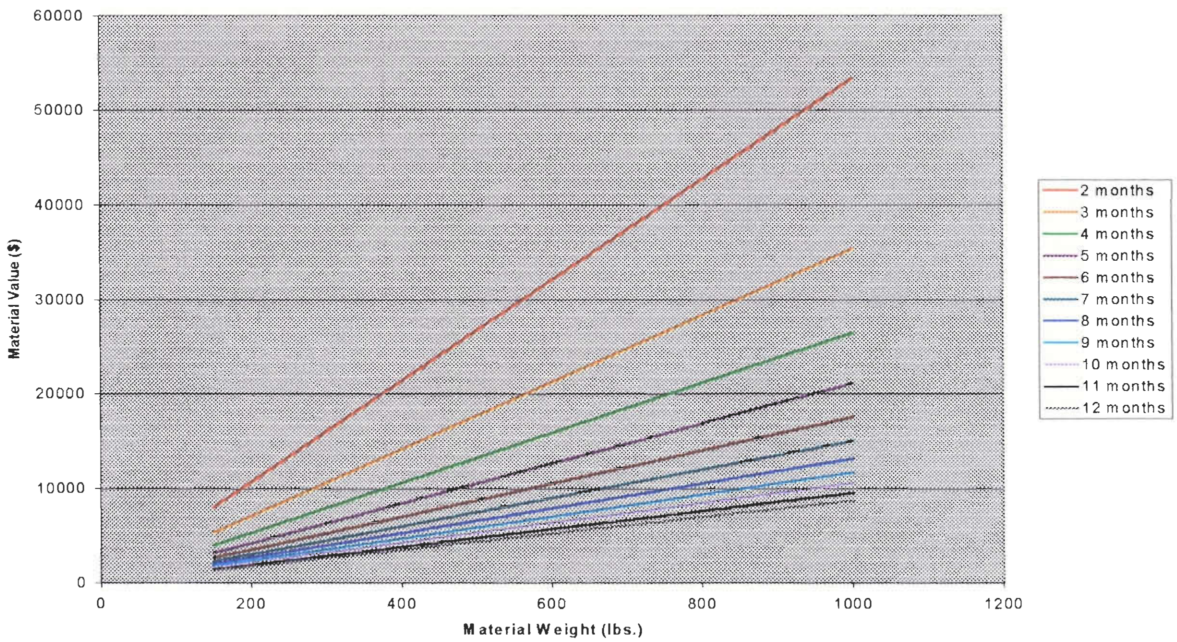

Figure 5-7 Inventory Carrying Costs for Two to Twelve Months vs. Next-Day Air Transportation Costs for Materials Over 150 pounds

Increasing Inventory vs. Air Transportation

The information given in **Figures 5-1** through **5-7** clearly shows that in order to save on costs, Caribe GE must increase inventories, and avoid air shipping of any materials. In almost all cases, the cost of a material must be extraordinarily high in order to justify air transportation. Everyday material orders will all fall below the calculated lines on our charts, indicating that air transportation is less economical than increasing inventory.

Control Measures

Following our analysis of the transportation costs and inventory carrying costs, we determined that a control process needed to be implemented in order to ensure compliance with the recommendations. The process will give management the ability to locate and fix problems as they arise, and thus should utilize near real-time feedback in order to be most beneficial.

The control process consists of a report that will be sent out on a weekly basis to each of the ten plants. The report for each plant will list all of the requestors and their related purchases for the week as well as the method of transport for each of the purchases. These shipments will be tracked using the waybill that is attached to the package. When the item arrives at the plant the waybill gives the method of transportation used to deliver the package, whether it was next-day air, second-day air, economy air, or boat. It is the receiver's job to match the waybill on the package with the PO for the package. Once this is accomplished, the information on how the package was shipped will then be entered into the computer under the corresponding PO number. A simple code for each type of transportation can be used to facilitate this process. As an example F1 could be used to denote Federal Express Next-Day air.

In addition to each PO having a waybill associated with it, it also has the appropriate requestor identified with the PO. As a result, for every requestor, a record can be kept of all PO's generated as well as how the shipments were transported to the plant. This information will then be used to create the weekly report. The report will display what percentage of each requestors PO's were sent by next-day air, second-day air, economy air and by boat. This report will be sent to all ten of the GE plants in Puerto Rico, as well as the Bayamon Sourcing Office on a weekly basis and reviewed during the weekly management meeting. A list will then be compiled of the ten requestors who use the highest percentage of premium air transportation from all of the ten plants. These top ten requestors will then be examined further in order to determine why they send such a high percentage of their items by premium air and any problems found will be corrected.

In addition to this first report, a second report will also be created. It will also list all of the requestors at each plant and will show the calculated cost for air transportation per requestor on a weekly basis. This will allow management to determine whether each individual requestor is above or below their projected budget for the month and any corrections can be made before a problem results at the end of the month. Also, on a weekly basis the waybills will be checked in order to see if they do in fact match up with a PO. This information will be used in order to make sure that the receiver is accurately tracking the receipt of shipments.

In order to utilize the graphs we generated for determining when it is more economical to increase inventory versus utilizing air transportation, the planners must be aware of the relative value of materials per pound. Currently there is no record of this information. We propose that in addition to tracking the method of shipping, weights of materials should also be recorded when personnel in receiving process the information from waybills. In this manner, planners will be able to determine the value of materials per pound and will therefor be able to use our graphs to determine when to utilize air services.

Through the use of this control system coupled with the charts provided previously, air transportation costs of inbound materials to General Electric's plants in Puerto Rico will be reduced considerably.

Chapter 6 **CONCLUSIONS AND RECOMMENDATIONS**

Introduction

The following chapter contains our conclusions and recommendations concerning the reduction of inbound air transportation costs, and are the result of our plant tours and analysis of southbound air transportation data for 1999. Our conclusions are a synopsis of our findings concerning the causes for high air transportation. Our recommendations map the proposed process for reducing air transportation costs. Within our recommendations, we will first review the causes of the high air transportation costs of the plants. We will then discuss the new control system, as it will be responsible for ensuring compliance with our recommendations. Within our discussion of the control system we have also highlighted the methods for determining the cause of high air transportation usage. For a more detailed explanation of the topics described within this chapter, please refer to Chapters 4 and 5, Results and Data Analysis.

Reasons for High Air Transportation Costs

During our plant visits we found several contributors to high air transportation costs. These contributors included insufficient forecasting of materials demand, suppliers not following GE's protocol for sending materials by air, inadequate or incorrect lead times, misused safety stocks, lack of communication with suppliers, and lack of consolidation of shipments from the same supplier. In addition, poor inventory tracking was also a problem. Due to the above reasons, an environment was created whereby materials must be transported by air in order to prevent production stops. By correcting the above problems, it is possible to eliminate this environment and allow most materials to be transported using ocean shipping.

With more reliable lead times, materials can be sent by ship and arrive in time to avoid production stops. There are three ways in which lead times can be made more reliable. The first is by providing accurate materials demand forecasts, which will improve reliability by alerting plant personnel in advance of material needs. Second, by improving communication with suppliers, the suppliers will be aware of the projected demand and accommodate the plant's needs in a timely manner. If the supplier is unaware of the projected demand they cannot anticipate when materials will be needed. As a result, lead times from the supplier are increased because the supplier will have to produce the material at the time the plant places an order. In addition, it is important that lead times be defined. If a planner is unaware of a supplier's lead times or has incorrect lead times for a supplier, the material may not arrive at the plant in time for production without requiring expedited air transportation.

In addition to increased reliability of lead times, safety stocks need to be calculated and used properly. When safety stocks are utilized, unexpected demand at a plant can be compensated for until replenishment materials arrive by boat. In many cases

materials planners are referring to reorder points as safety stocks. There needs to be an increased awareness regarding the definition and purpose of safety stocks to avoid frequent depletion of materials.

In addition to improving reliability, correcting problems with suppliers will keep air transportation costs down. Some suppliers transport materials by air as a default, despite the fact that this service is reserved for special circumstances. A special circumstance occurs when there is an emergency at a plant requiring materials to be transported by air to avoid a production stop. Suppliers' transportation defaults should be verified and those with defaults to ship by air should be changed. Eliminating air shipping defaults will save a considerable amount of money.

Another reason for high air transportation costs is poor inventory tracking. If managers are unaware of the quantity of material in inventory they cannot predict when stocks will be depleted. In addition, they may believe a material is in stock when it has already been used in production. This circumstance creates a need to have materials shipped to the plant using air transportation in order to prevent production stops. In the case of GE's plants in Puerto Rico, once material is sent from the stockroom to the production floor, they are unable to track it's usage until it needs to be replaced, which in many cases is too late to allow for ocean transportation. In order to prevent this, fewer materials should be kept on the production floor to facilitate accurate inventory tracking.

By creating an environment where lead times are more predictable and suppliers follow the proper protocol, it will be possible to send almost all of Caribe GE's materials by ocean freighter. Even if demand is extremely volatile, properly calculated and used safety stocks should alleviate the need for air shipping. Sending materials via ocean freighter as an alternative to using air transportation will constitute significant savings for Caribe GE.

Control System

In order to ensure that our recommendations are followed and the usage of air transportation is maintained at a minimal level, we have proposed a control system for tracking the usage of air transportation services. The control system is a diagnostic tool that will be used to report high usage of air transportation, along with the responsible parties. High usage of air transportation can either occur on a plant level or on an individual requestor level, depending upon how widespread air transportation usage is at a particular plant.

The control system consists of two reports that will be created in the Sourcing office in Bayamon, Puerto Rico on a weekly basis. The first report is divided by plant and then by requestor, and will show for each requestor the percentage of their shipments that were sent via air transportation. A list of the ten requestors with the highest percentages of air transportation will then be reviewed at the weekly management meeting in Bayamon. These top ten requestors will then be notified and their routines will be examined in order to determine the cause for sending such a high percentage of their materials by air transport.

The second weekly report will display the monthly air transportation budget for each requestor and whether they will exceed that budget based on their projected expenditure for the month. This report will be distributed among the plant managers at all ten of GE's plants in Puerto Rico, enabling the current spending to be tracked on a weekly basis. Any requestors that are projected to exceed their allocated budget will be contacted and measures will be taken to correct the spending.

Once the top ten requestors have been identified, the first item that will be examined is the shipments each requestor sent by air for the week. The shipments will be verified to determine whether the requestor followed the correct protocol for ordering these particular materials. Issues such as consolidating shipments from single suppliers as well as the supplier's default setting for transporting the material will be examined. In addition, parameters such as lead-time, safety stock, inventory levels, Kanban sizes, and reorder points will be checked to ensure accuracy. If the high usage of air transportation is a plant wide problem, issues such as inventory control and management as well as improved forecasting of materials demand will be examined.

We also propose that Caribe GE implement a positive reinforcement system where individual requestors or manufacturing plants who exhibit significant improvement in their air transportation spending are rewarded. With this proposed control system, problems and excellence will be identified in a near real time manner. In addition, because the system identifies requestors, as well as to entire plants, it will be easier to locate and fix problems associated with the high usage of air transportation. If our recommendations are implemented, Caribe General Electric will achieve a reduction in their current air transportation costs that is well over 40 percent.

Appendix A **GE INDUSTRIAL SYSTEMS MISSION AND ORGANIZATION**

The following information was taken from the GE web page: http://www.ge.com and the Interactive Qualifying Project (IQP) entitled *Determining The Feasibility Of An Automation Line For Caribe GE Of Vega Baja* completed on May 5, 1998. The authors of this IQP are Karachristos, Williams, and Woodcock.

General Electric traces its beginnings to Thomas A. Edison, who established Edison Electric Light Company in 1878. In 1892, a merger of Edison General Electric Company and Thomson-Houston Electric Company created General Electric Company. GE is the only company listed in the Dow Jones Industrial Index today that was also included in the original index in 1896.

GE is a diversified services, technology, and manufacturing company with a commitment to achieving global leadership in each of its businesses. GE operates in more than 100 countries around the world, while employing 340,000 people, including 197,000 in the United States. John F. Welch has been Chairman and Chief Executive Officer of the company since 1981. GE is one of the largest and most diversified companies in the world, with twelve principal businesses. The following list gives a brief description of each of the twelve business divisions within GE.

GE **Aircraft Engines** is the world's largest producer of large and small jet engines for commercial and military aircraft. Throughout the 1990s, more than 50% of the world's large commercial jet engine orders were awarded to GE or CFM International, a joint company of GE and Snecma of France.

GE **Appliances** is one of the largest manufacturers of major appliances in the world. Products include refrigerators and freezers, speed cook ovens, electric and gas ranges and cook tops, microwave ovens, washers and dryers, dishwashers, disposals and compactors, room air conditioners and water purification systems. These products carry the brand names Monogram, Profile Performance, Profile, GE, and Hotpoint.

GE **Capital Services** is a diversified financial services company that creates comprehensive solutions to increase client productivity and efficiency. Its operations consist of 28 distinct businesses in the areas of Equipment Management, Consumer Services, Mid-Market Financing, Specialized Financing and Specialty Insurance.

GE **Industrial Systems** is a leading supplier of products used to distribute, protect, operate and control electrical power and equipment, as well as services for commercial and industrial applications. Major products and services include circuit breakers, switches, transformers, switchboards, switchgear, meters, relays, adjustable-speed drives, control and process automation systems, a full range of AC and DC electric motors, and comprehensive technical engineering and power management solutions.

GE **Lighting** is a leading supplier of lighting products for global consumer, commercial, and industrial markets. Products include incandescent, fluorescent, high-intensity discharge, halogen and holiday lamps, along with portable lighting fixtures, lamp components and quartz products.

GE **Medical Systems** is a world leader in medical diagnostic imaging technology, services and health care productivity. Products include computed tomography (CT) scanners, x-ray equipment, magnetic resonance imaging (MR) systems, nuclear medicine cameras, ultrasound systems, patient monitoring devices, and mammography systems.

The **National Broadcasting Company (NBC)** is owned and operated by GE and is one of the world's leading television networks with a variety of news, sports and entertainment programming.

GE **Plastics** is a world leader in versatile, high-performance engineered plastics used in computers, electronics, data storage, office equipment, the automotive industry, building and construction, and other industries.

GE **Power Systems** is a world leader in the design, manufacture, and service of gas, steam, and hydroelectric turbines and generators for power production, pipeline, and industrial applications.

GE **Transportation Systems** manufactures more than half of the diesel freight locomotives in North America.

Financial Highlights

General Electric Company and consolidated affiliates
(Dollar amounts in millions-per share in dollars)

	1999	**1998**	**1997**	**1996**
Revenues	$112,000	$100,469	$90,840	$79,179
Net Earnings	10,700	9,296	8,203	7,280
Dividends Declared		4,081	3,535	3,138
Per Share:				
Net Earnings	$3.22	$2.80	$2.46	$2.16
Dividends Declared	$1.64	$1.25	$1.08	$0.95

Number of Shareowners:	2.1 Million
Stock Splits:	GE shareowners have approved four 2-for-1 stock splits since 1983, most recently in 1997. One GE share purchased before 1926 is now worth 1,536 shares.
1998 Total Assets:	$355 Billion

Rankings

World's Most Admired Company - ***Fortune*** (1998, 1999)

World's Most Respected Co. - ***Financial Times*** (1998, 1999)

America's Most Admired Company - ***Fortune*** (1998, 1999, 2000)

America's Greatest Wealth Creator - ***Fortune*** (1998, 1999)

First - ***Forbes World Super 50*** (1998, 1999)

First - ***Forbes Super 100*** (1998, 1999)

First - ***Business Week*** 1000 (1999)

First - ***Business Week's 25 Best Boards of Directors*** (2000)

Fifth - ***Fortune*** 500. If ranked independently, nine of GE's businesses would be on the ***Fortune*** 500.

The ten GE manufacturing plants in Puerto Rico are located in Añasco, Arecibo, Humacao, Palmer, Patillas, San German, Vega Alta Controls, Vega Alta Pilot, Vega Baja, and Vieques. Below are descriptions of the operations completed at each plant.

1. ***Añasco*** – Electronic relays, switches, and other control devices are produced here.
2. ***Arecibo*** – This plant manufactures fairly large industrial breakers, causing the plant to have a lower production volume and little mix of products. The plant also provides plating operations for all other GE plants on the island.
3. ***Humacao*** – Production here consists of molded plastic parts and silver contacts for use in circuit breakers. The plant supplies only other GE plants on the island.

4. ***Palmer*** – Parts for use in Ground Fault Protection devices are made here. Palmer is the only plant with unionized labor. The presence of the union makes it very difficult for GE to make changes in their manufacturing processes.
5. ***Patillas*** – Production here consists of electric boards for other GE divisions. The plant has a high volume and a mixture of products.
6. ***San German*** – This plant has a high volume with a low mix production of residential circuit breakers.
7. ***Vega Alta Controls*** – Control equipment, switches, and relays are manufactured here.
8. ***Vega Alta Pilot*** – This plant fabricates parts and mold casings for several other plants.
9. ***Vega Baja*** – This plant has a very low volume and a high mix of products. They make several different sizes of industrial circuit breakers, including the largest type made on the island.
10. ***Vieques*** – This small plant produces switches and fuses.

General Electric in Puerto Rico has commissioned several past Interactive Qualifying Projects, through the WPI Project Center. The president of Caribe GE, Paul Sledzik, is a WPI alumnus and is very interested in the progress of the undergraduate students.

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AUTHORIZATION

❍ ***INTER-ISLAND SPECIAL TRIP*** ❍ ***AIR FREIGHT***

DATE: ____________________ REQUESTOR: ____________________

SUPPLIER: ____________________ PLANT: ____________________

MATERIAL ID: ____________________ PO#: ____________________

WEIGHT: ____________________ # OF PIECES: ____________________

DESCRIPTION: ____

REASON FOR EXPEDITED SERVICE:

- ☐ VENDOR LATE
- ☐ QC REJECTION
- ☐ REJECTED MATERIAL
- ☐ INCORRECT FORECAST
- ☐ MR ISSUED LATE
- ☐ PO ISSUED LATE
- ☐ OTHER: ____________________

AIR CARRIER: ____________________

- ☐ FEDEX
- ☐ EMERY
- ☐ CARIBBEAN AIR
- ☐ OTHER (specify): ____________________

SERVICE REQUESTED:

☐ SAME DAY ☐ NEXT DAY ☐ SECOND DAY ☐ ECONOMY

COST $: ____________________ (if available)

COMMENTS: ____

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____

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APPROVED BY: ____________________ or ____________________

Plant Manager Materials Manager

GE Industrial Systems

To Our Mainland Suppliers
Logistic Change for Caribe GE Puerto Rico Plants

(Arecibo, Añasco, Controls, Humacao, Palmer, Patillas, San Germán, Vega Baja, Vega Alta-Pilot)

Our strategy for all Southbound shipments to Caribe GE PR has been changed. We need your total involvement and all your necessary personnel (shipping, data-entry, logistics manager, etc.) to be aware of our strategy and follow it.

NORMAL SHIPMENTS	*ADDRESS*
• *Shipments under 200 lbs: RPS Collect*	*Caribe GE Plant Name* *c/o Commercial Warehouse and Cartage* *285 Ridge Road* *Suite 3* *Dayton, NJ 08810*
• *Shipments over 200 lbs:* ▪ *Roadway Express* ▪ *Consolidated Freight* ▪ *APA World Transport*	

AIR SHIPMENTS	*ADDRESS*
• *Next Day:* ▪ *Under 150 lbs: Federal Express* ▪ *Over 150 lbs: Caribbean Transp. Services* ▪ *Or call the Buyer*	*Caribe GE Plant Name* *Physical Plant Address in PR*
• *2nd Day:* ▪ *Under 150 lbs: Airborne / Emery* ▪ *Over 150 lbs: Caribbean Transp. Services*	*Caribe GE Plant Name* *Physical Plant Address in PR*
• *3rd Day:* ▪ *Under 150 lbs: Fedex* ▪ *Over 150 lbs: Caribbean Transp. Services*	*Caribe GE Plant Name* *Physical Plant Address in PR*

CRITICAL NOTES

- *Air shipments are only for exceptions and must be authorized by the buyer or an authorized person at the plant.*
- *Transportation charges not in compliance with this strategy are debited back to the supplier based on Caribe GE rates.*
- *All shipments to be sent collect should indicate correct account and tax exempt number.*
- *Never air ship material to the Dayton, N.J. warehouse.*

Questions: Call José Morales: (787) 288-2304, Guillermo López: (787) 288-2328 or the GE Buyer (787) 288-2300

Contact Carriers:

- *APA : 1-800-951-9777*
- *RPS : 1-800-290-9529*
- *Caribbean Transp. Services: 1-800-767-2494*
- *Roadway Express: 1-800-257-2837*
- *Consolidated Freightway: 1-800-543-9942*

Exception: Silver suppliers are not part of this change. Please continue with original agreement.

GE is self insured. No insurance value should be included on airbills.

1999 Small Parcel Air Rates					
	Federal Express		EMERY Worldwide		
Lbs.	PR PO	PR Econ	PR AM	PR PM	PR 2 Day
Letter	$ 9.25	N/A	N/A	N/A	N/A
1	$ 10.65	$ 7.60	$ 25.00	$ 25.00	$ 25.00
2	$ 10.65	$ 7.60	$ 25.00	$ 25.00	$ 25.00
3	$ 11.15	$ 7.60	$ 25.00	$ 25.00	$ 25.00
4	$ 11.65	$ 7.60	$ 25.00	$ 25.00	$ 25.00
5	$ 12.15	$ 7.60	$ 25.00	$ 25.00	$ 25.00
6	$ 13.74	$ 8.87	$ 25.00	$ 25.00	$ 25.00
7	$ 14.26	$ 10.14	$ 25.00	$ 25.00	$ 25.00
8	$ 14.78	$ 11.41	$ 25.00	$ 25.00	$ 25.00
9	$ 15.30	$ 12.68	$ 25.00	$ 25.00	$ 25.00
10	$ 15.82	$ 13.95	$ 25.00	$ 25.00	$ 25.00
11	$ 16.34	$ 15.05	$ 25.00	$ 25.00	$ 25.00
12	$ 16.86	$ 16.15	$ 25.00	$ 25.00	$ 25.00
13	$ 17.90	$ 17.25	$ 25.00	$ 25.00	$ 25.00
14	$ 18.94	$ 18.35	$ 25.00	$ 25.00	$ 25.00
15	$ 19.98	$ 19.45	$ 25.00	$ 25.00	$ 25.00
16	$ 21.02	$ 20.55	$ 25.00	$ 25.00	$ 25.00
17	$ 22.06	$ 21.65	$ 25.00	$ 25.00	$ 25.00
18	$ 23.10	$ 22.75	$ 25.00	$ 25.00	$ 25.00
19	$ 24.14	$ 23.85	$ 25.00	$ 25.00	$ 25.00
20	$ 25.18	$ 24.68	$ 25.00	$ 25.00	$ 25.00
21	$ 26.22	$ 25.51	$ 25.00	$ 25.00	$ 25.00
22	$ 27.26	$ 26.34	$ 25.00	$ 25.00	$ 25.00
23	$ 28.30	$ 27.17	$ 25.00	$ 25.00	$ 25.00
24	$ 29.34	$ 28.00	$ 25.00	$ 25.00	$ 25.00
25	$ 30.38	$ 28.83	$ 25.00	$ 25.00	$ 25.00
26	$ 31.16	$ 29.66	$ 25.00	$ 25.00	$ 25.00
27	$ 31.94	$ 30.49	$ 25.00	$ 25.00	$ 25.00
28	$ 32.72	$ 31.32	$ 25.00	$ 25.00	$ 25.00
29	$ 33.50	$ 32.15	$ 25.00	$ 25.00	$ 25.00
30	$ 34.28	$ 32.98	$ 25.25	$ 25.25	$ 25.00
31	$ 35.06	$ 33.81	$ 26.00	$ 26.00	$ 25.00
32	$ 35.84	$ 34.64	$ 26.50	$ 26.50	$ 25.25
33	$ 36.62	$ 35.47	$ 27.50	$ 27.50	$ 26.00
34	$ 37.40	$ 36.30	$ 28.25	$ 28.25	$ 26.75
35	$ 38.18	$ 37.13	$ 30.25	$ 30.25	$ 27.50
36	$ 38.96	$ 37.96	$ 31.00	$ 31.00	$ 28.00
37	$ 39.74	$ 38.79	$ 31.75	$ 31.75	$ 28.75
38	$ 40.52	$ 39.62	$ 32.50	$ 32.50	$ 29.50
39	$ 41.30	$ 40.45	$ 33.25	$ 33.25	$ 30.00
40	$ 42.08	$ 41.28	$ 34.00	$ 34.00	$ 30.75
41	$ 42.86	$ 42.11	$ 34.50	$ 34.50	$ 31.75

1999 Small Parcel Air Rates					
	Federal Express		EMERY Worldwide		
Lbs.	PR PO	PR Econ	PR AM	PR PM	PR 2 Day
42	$ 43.64	$ 42.94	$ 35.25	$ 35.25	$ 32.00
43	$ 44.42	$ 43.77	$ 36.00	$ 36.00	$ 32.75
44	$ 45.20	$ 44.60	$ 36.75	$ 36.75	$ 33.25
45	$ 45.98	$ 45.15	$ 37.50	$ 37.50	$ 34.00
46	$ 46.76	$ 45.70	$ 38.25	$ 38.25	$ 34.75
47	$ 47.54	$ 46.25	$ 39.00	$ 39.00	$ 35.50
48	$ 48.32	$ 46.80	$ 40.00	$ 40.00	$ 36.25
49	$ 49.10	$ 47.35	$ 40.75	$ 40.75	$ 37.00
50	$ 49.88	$ 47.90	$ 41.50	$ 41.50	$ 37.75
51	$ 51.44	$ 48.84	$ 44.50	$ 44.50	$ 38.50
52	$ 52.36	$ 49.78	$ 45.25	$ 45.25	$ 39.25
53	$ 53.27	$ 50.72	$ 46.00	$ 46.00	$ 40.00
54	$ 54.19	$ 51.66	$ 47.00	$ 47.00	$ 40.75
55	$ 55.10	$ 52.60	$ 47.75	$ 47.75	$ 41.50
56	$ 56.02	$ 53.54	$ 48.75	$ 48.75	$ 42.25
57	$ 56.93	$ 54.48	$ 49.75	$ 49.75	$ 43.00
58	$ 57.85	$ 55.42	$ 50.50	$ 49.75	$ 43.75
59	$ 58.76	$ 56.36	$ 51.25	$ 51.25	$ 44.50
60	$ 59.68	$ 57.30	$ 52.00	$ 52.00	$ 45.25
61	$ 60.59	$ 58.24	$ 53.00	$ 53.00	$ 46.00
62	$ 60.51	$ 59.18	$ 53.50	$ 53.50	$ 46.75
63	$ 61.42	$ 60.12	$ 54.50	$ 54.50	$ 47.50
64	$ 62.34	$ 60.60	$ 55.25	$ 55.25	$ 48.50
65	$ 63.25	$ 61.00	$ 56.25	$ 56.25	$ 49.00
66	$ 64.17	$ 61.94	$ 57.00	$ 57.00	$ 49.75
67	$ 65.08	$ 62.88	$ 57.75	$ 57.75	$ 50.50
68	$ 66.00	$ 63.82	$ 58.75	$ 58.75	$ 51.25
69	$ 66.91	$ 64.76	$ 59.50	$ 59.50	$ 51.50
70	$ 67.83	$ 65.70	$ 60.25	$ 60.25	$ 51.75
71	$ 68.74	$ 66.64	$ 61.25	$ 61.25	$ 52.00
72	$ 69.66	$ 67.58	$ 62.00	$ 62.00	$ 52.00
73	$ 70.57	$ 68.52	$ 62.75	$ 62.75	$ 52.00
74	$ 71.49	$ 69.46	$ 63.75	$ 63.75	$ 52.00
75	$ 72.40	$ 70.40	$ 64.50	$ 64.50	$ 52.00
76	$ 73.32	$ 71.34	$ 65.25	$ 65.25	$ 52.00
77	$ 74.24	$ 72.28	$ 66.25	$ 66.25	$ 52.00
78	$ 75.15	$ 73.22	$ 66.75	$ 66.75	$ 52.00
79	$ 76.07	$ 74.16	$ 67.75	$ 67.75	$ 52.00
80	$ 76.98	$ 75.10	$ 68.50	$ 68.50	$ 52.00
81	$ 77.90	$ 76.04	$ 69.50	$ 69.50	$ 52.00
82	$ 78.81	$ 76.98	$ 70.25	$ 70.25	$ 52.00
83	$ 79.73	$ 77.92	$ 71.00	$ 71.00	$ 52.00
84	$ 80.64	$ 78.86	$ 71.75	$ 71.75	$ 52.00
85	$ 81.56	$ 79.80	$ 72.75	$ 72.75	$ 52.00
86	$ 82.47	$ 80.74	$ 73.50	$ 73.50	$ 52.00

1999 Small Parcel Air Rates					
	Federal Express		EMERY Worldwide		
Lbs.	PR PO	PR Econ	PR AM	PR PM	PR 2 Day
87	$ 83.39	$ 81.68	$ 74.50	$ 74.50	$ 52.00
88	$ 84.30	$ 81.68	$ 75.25	$ 75.25	$ 52.00
89	$ 85.22	$ 82.00	$ 76.00	$ 76.00	$ 52.00
90	$ 86.13	$ 82.00	$ 76.75	$ 76.75	$ 52.00
91	$ 87.05	$ 82.00	$ 77.75	$ 77.75	$ 52.00
92	$ 87.96	$ 82.00	$ 78.50	$ 78.50	$ 52.00
93	$ 88.88	$ 82.00	$ 79.25	$ 79.25	$ 52.00
94	$ 89.79	$ 82.00	$ 80.00	$ 80.00	$ 52.00
95	$ 90.71	$ 82.00	$ 80.00	$ 80.00	$ 52.00
96	$ 91.62	$ 82.00	$ 80.00	$ 80.00	$ 52.00
97	$ 92.54	$ 82.00	$ 80.00	$ 80.00	$ 52.00
98	$ 93.45	$ 82.00	$ 80.00	$ 80.00	$ 52.00
99	$ 94.37	$ 82.00	$ 80.00	$ 80.00	$ 52.00
100	$ 112.00	$ 82.00	$ 80.75	$ 80.75	$ 52.50
101	$ 113.12	$ 82.82	$ 81.50	$ 81.50	$ 53.00
102	$ 114.24	$ 83.64	$ 82.25	$ 82.25	$ 53.50
103	$ 115.36	$ 84.46	$ 83.00	$ 83.00	$ 54.00
104	$ 116.48	$ 85.28	$ 83.75	$ 83.75	$ 54.50
105	$ 117.60	$ 86.10	$ 84.50	$ 84.50	$ 55.00
106	$ 118.72	$ 86.92	$ 85.25	$ 85.25	$ 55.50
107	$ 119.84	$ 87.74	$ 86.00	$ 86.00	$ 56.00
108	$ 120.96	$ 88.56	$ 86.75	$ 86.75	$ 56.50
109	$ 122.08	$ 89.38	$ 87.50	$ 87.50	$ 57.00
110	$ 123.20	$ 90.20	$ 88.25	$ 88.25	$ 57.50
111	$ 124.32	$ 91.02	$ 89.00	$ 89.00	$ 58.00
112	$ 125.44	$ 91.84	$ 89.75	$ 89.75	$ 58.50
113	$ 126.56	$ 92.66	$ 90.50	$ 90.50	$ 59.00
114	$ 127.68	$ 93.48	$ 91.25	$ 91.25	$ 59.50
115	$ 128.80	$ 94.30	$ 92.00	$ 92.00	$ 60.00
116	$ 129.92	$ 95.12	$ 92.75	$ 92.75	$ 60.50
117	$ 131.04	$ 95.94	$ 93.50	$ 93.50	$ 61.00
118	$ 132.16	$ 96.76	$ 94.25	$ 94.25	$ 61.50
119	$ 133.28	$ 97.58	$ 95.00	$ 95.00	$ 62.00
120	$ 134.40	$ 98.40	$ 95.75	$ 95.75	$ 62.50
121	$ 135.52	$ 99.22	$ 96.50	$ 96.50	$ 63.00
122	$ 136.64	$ 100.04	$ 97.25	$ 97.25	$ 63.50
123	$ 137.76	$ 100.86	$ 98.00	$ 98.00	$ 64.00
124	$ 138.88	$ 101.68	$ 98.75	$ 98.75	$ 64.50
125	$ 140.00	$ 102.50	$ 99.50	$ 99.50	$ 65.00
126	$ 141.12	$ 103.32	$ 100.25	$ 100.25	$ 65.50
127	$ 142.24	$ 104.14	$ 101.00	$ 101.00	$ 66.00
128	$ 143.36	$ 104.96	$ 101.75	$ 101.75	$ 66.50
129	$ 144.48	$ 105.78	$ 102.50	$ 102.50	$ 67.00
130	$ 145.60	$ 106.60	$ 103.25	$ 103.25	$ 67.50
131	$ 146.72	$ 107.42	$ 104.00	$ 104.00	$ 68.00

1999 Small Parcel Air Rates					
	Federal Express		EMERY Worldwide		
Lbs.	PR PO	PR Econ	PR AM	PR PM	PR 2 Day
132	$ 147.84	$ 108.24	$ 104.75	$ 104.75	$ 68.50
133	$ 148.96	$ 109.06	$ 105.50	$ 105.50	$ 69.00
134	$ 150.08	$ 109.88	$ 106.25	$ 106.25	$ 69.50
135	$ 151.20	$ 110.70	$ 107.00	$ 107.00	$ 70.00
136	$ 152.32	$ 111.52	$ 107.75	$ 107.75	$ 70.50
137	$ 153.44	$ 112.34	$ 108.50	$ 108.50	$ 71.00
138	$ 154.56	$ 113.16	$ 109.25	$ 109.25	$ 71.50
139	$ 155.68	$ 113.98	$ 110.00	$ 110.00	$ 72.00
140	$ 156.80	$ 114.80	$ 110.75	$ 110.75	$ 72.50
141	$ 157.92	$ 115.62	$ 111.50	$ 111.50	$ 73.00
142	$ 159.04	$ 116.44	$ 112.25	$ 112.25	$ 73.50
143	$ 160.16	$ 117.26	$ 113.00	$ 113.00	$ 74.00
144	$ 161.28	$ 118.08	$ 113.75	$ 113.75	$ 74.50
145	$ 162.40	$ 118.90	$ 114.50	$ 114.50	$ 75.00
146	$ 163.52	$ 119.72	$ 115.25	$ 115.25	$ 75.50
147	$ 164.64	$ 120.54	$ 116.00	$ 116.00	$ 76.00
148	$ 165.76	$ 121.36	$ 116.75	$ 116.75	$ 76.50
149	$ 166.88	$ 122.18	$ 117.50	$ 117.50	$ 77.00
150	$ 168.00	$ 123.00	$ 118.25	$ 118.25	$ 77.50

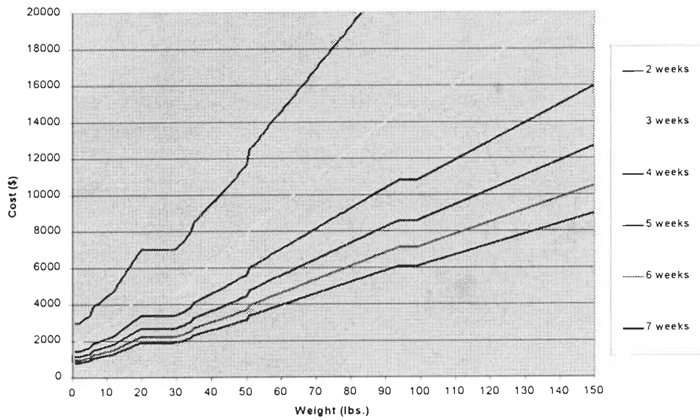
Problem: Caribe GE's transportation costs are undesirably high due to the overuse of air transportation. The goal of our project was to make recommendations that will reduce these air transportation costs by 40 percent or more.

Caribe GE's air transportation costs for 1999 were $1,628,690. A 40 percent reduction will constitute a savings of over $650,000.

Recommendations:

- Use receiving to match waybills with PO's
- Track air shipments by requestor
- Develop enhanced forecasting tools
- Improve communication with suppliers
- Consolidate shipments from the same supplier

$$MaterialValue = \frac{TransportationCost}{(DailyInventoryCarryingCost)(DaysInInventory)}$$



Carrying Inventory vs. Shipping by Next-Day Air

Air Transportation is the Last Resort

- Would it be cheaper to increase inventory?
- What percentage of the material value is being spent on transportation?
- Are there frequent problems with a supplier?
- Can lead times be decreased to allow for ocean transport?

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