Impact of Product Configurations on Lead Time and Profits

by

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Abstract

This thesis analyzes the configurations offered in PictureTel's product lines. PictureTel offers a number of options within each of its product lines resulting in a large number of possible configurations. However, only a small subset of this large number of configurations makes up a large part of the sales. PictureTel wants to understand the implications for cost and lead times of cutting down it product variations to those that comprise 80% of sales.

The thesis presents analysis of various components of lead times to show how a slimmer product configuration set will impact each of the components and hence the overall lead time. The thesis also examines various components of variable cost and models the effect of a leaner set of configurations on costs and hence profits. The lead time and cost analysis is the basis for a recommendation of when and how PictureTel should move to a smaller number of configurations within each product line.

The thesis also examines other options, like mass customization and platform design, open to PictureTel, if the market becomes increasingly heterogeneous.

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1. Introduction

It was the 1920s and Ford's Model T was the hottest car. It was a sellers market and Henry Ford said you could have any color car you want as long as it was black. Seven decades have passed and the car industry has come a long way. Today we not only have a choice of color but also different sizes and options.

The industrial revolution of the nineteenth century began substituting machines for human skill in production of goods. By the twentieth century the United States of America further extended this concept and became a world manufacturing leader by creating the American Manufacturing System. The American Manufacturing System was essentially a focus on the process of production, the development of interchangeable parts, and the utilization of flexibility and ingenuity of workers. The American Manufacturing System was further extended in the twentieth century by Henry Ford and others to create the Mass Production System. A Mass Production System was ideally suited for producing identical copies of a product with great precision and efficiency (Pine, 1993, P. 3.)

With increasing competition and product quality, customers of many products are now demanding greater variety. One of the problems facing companies today is dealing with a demand that is increasingly heterogeneous. Management consultants have popularized philosophies like "Mass Customization"(Pine, 1993) and "One to One Marketing"(Rogers and Peppers, 1993). But are there cases where it is better economics to offer a subset of all the demanded variations and forgo a few sales? This is the fundamental question explored for PictureTel products in this thesis.

1.1 Problem Statement

PictureTel manufactures videoconferencing equipment. It offers over a thousand variations within some of its product lines. Customers can order highly customized versions of PictureTel products. However, PictureTel products were not designed to be easily configurable. Allowing customers to order from a large number of variations

entails high costs and large lead times. In this context PictureTel was interested in answering the following questions

- What configurations do customers actually buy?

PictureTel suspected that customers favored a small subset of the total configurations offered. If that was indeed the case the company was interested in understanding

- What are the implications of lesser options for lead times of products?
- What are the implications of smaller number of variations for costs and revenues?

This thesis seeks to answer the three questions presented above.

1.2 The Company

Over the past six years PictureTel's revenues have been growing at a rate of 40-68%. Like most young high tech companies, PictureTel's competency is its sophisticated technology. Its crown jewels are the compression algorithms which enable quality videoconferencing in a bandwidth scarce world. PictureTel is pushing aggressively to integrate marketing and manufacturing with its technology strength to maintain a leadership position in videoconferencing.

PictureTel has competed as a technology leader until now. It has been a high quality high cost manufacturer. PictureTel has 50% market share in the high end dedicated hardware videoconferencing systems. New competitors like Sony are now entering the videoconferencing market. In order to protect its market leadership position PictureTel has to not only push technology but also its marketing and manufacturing competence. In light of the potential threats, answering the three questions presented in the previous section is important to PictureTel, in maintaining its competitive edge.

1.3 Overview of Remaining Chapters

The remaining chapters seek to answer the three questions posed in the problem statement.

Chapter 2 provides an overview of the industry and PictureTel's background and product information. Chapter 3 provides analysis of sales data of two PictureTel product lines. Data for four quarters are analyzed to remove any seasonality inherent in the data. Chapter 4 attempts to analyze the lead time implications of offering a smaller number of variations within each product line. Chapter 5 provides a model to analyze cost savings from a more restricted product variation offering. Chapter 6 ties up the results from Chapter 3 - 5 and presents recommendations. Chapter 7 enumerates other option available to PictureTel to deal with the large configuration issue and deal with the coming competition in videoconferencing.

2. Videoconferencing and PictureTel

2.1 Videoconferencing Basics

In the narrow sense of the word, videoconferencing is used to refer to a video phone. In a broad sense however, videoconferencing encompasses video, audio and document conferencing. Throughout this document videoconferencing implies the latter.

Videoconferencing systems can be mainly classified into two types. The high end conferencing systems, which use expensive dedicated processing hardware, a television monitor, and a camera, are referred to as *room systems* or *group systems* in this document. The other class of systems called the *desktop systems* or *personal video conferencing systems* use a Personal Computer (PC) and a camera for conferencing. Some desktop solutions perform all their data processing in software, while others use a plug in card in addition to software, to speed up processing.

Figure 2.1 shows the basic videoconferencing process. At the senders end, the video camera, microphone, and document capture equipment capture the video, audio and document image respectively.

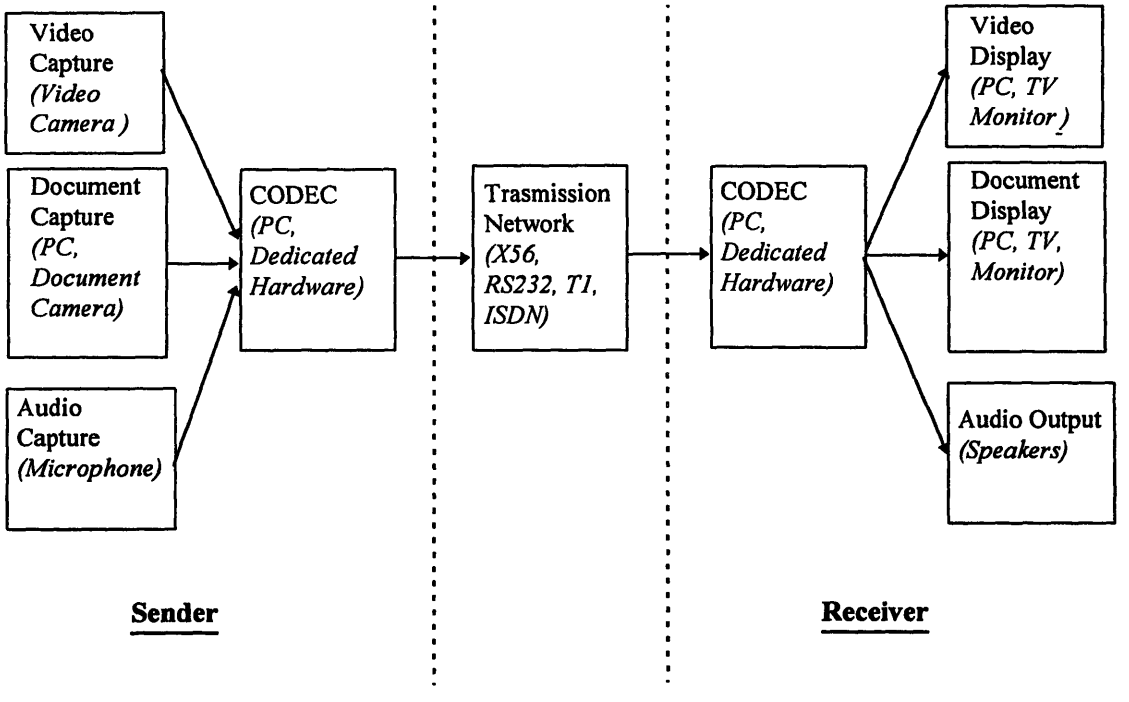


Figure 2.1: Videoconferencing Process

The document capture equipment is either a document camera in a room system or a PC in the desktop system. The video, audio, and document data is compressed and merged by a CODEC (Compressing-Decompressing module). CODEC is dedicated hardware and software in a room system, or software and possibly a plug in card in a desktop system. Processing on dedicated hardware is faster since the algorithms are implemented in hardware as opposed to software. The merged and compressed data is transmitted to the receiver over a switched digital network using X56, RS232, T1 or ISDN protocol. The receiving equipment separates the data into video, audio and document streams and decompresses each stream. The video and document is displayed on a TV monitor in the room systems products and on a PC monitor in the desktop system products. The audio output goes to the speakers.

The main bottle neck in this process is the bandwidth (the number of bits per second transmitted) of the transmission network. Since bandwidth is at a premium, compression algorithms have become very important. Compression is the process of taking a particular selection of data and reducing it to a smaller size, in such a way that it can be expanded back to its original size when needed again. The better the compression algorithm, the more information can be squeezed into each bit transmitted. Of the three types of information transmitted, video needs the largest bandwidth. Hence, video compression algorithms have become a very hot area in signal processing. In the past a good proprietary video compression algorithm and a successful implementation was a great source of competitive advantage for a company a company like PictureTel.

Most videoconferencing implementations use "lossy" compression techniques. The idea behind lossy compression is to reduce a particular image to a smaller size than what is possible with conventional techniques, by erasing or losing the details in an image that are least noticeable. A good example of a lossy compression is compressing an image of a meadow by erasing the details between every blade of grass. The two most popular

implementations of lossy compression are Motion-JPEG (MPEG) and Wavelet[1] (Digital Video Newsletter, Jan 1997.)

With lossy compression, room systems can attain the 30 frames per second rate necessary for a smooth motion video. Currently six 64k bit ISDN lines are needed to accomplish this frame rate. The technology of desktop systems allows anywhere from 5 to 15 frames per second over standard telephone lines with 28.8 Kpbs modems (Digital Video Newsletter, Jan 1997.)

2.2 The Industry

In 1964 AT&T/Bell Laboratories introduced the Videophone. This was the first face-to-face communication via electronic medium. Since then, technological innovations have produced astounding advances bringing forth videoconferencing systems beyond anything imagined in 1964. The market for videoconferencing equipment and services is constantly pioneering new approaches to demonstrate the capabilities of full motion video as an interactive collaboration and communication tool (PR Newswire, March 24, 1997.)

Videoconferencing has been presented as "the next big thing" since the late 1980s. But the technology finally became affordable enough to make it useable in the mid 1990s. There are two reasons for the false starts before videoconferencing finally took off: 1) The absence of infrastructure to carry the necessary video bandwidth. 2) The lack of sufficiently sophisticated algorithms and the cost of implementing them in silicon. All this has changed in the 1990s. The U.S. videoconferencing systems and service market totaled $2.94 billion in 1995. Frost & Sullivan, a Framingham Massachusetts based market research company, forecasts that this figure will reach $34.76 billion by 2002, growing at an annual compound rate of 42.3 percent (Research Studies, August 1996.)

2.2.1 Applications

Due to falling costs and improving quality, videoconferencing is finding applications in a variety of areas. Videoconferencing is having an impact in business, healthcare, education

[1] These algorithms can compress 90 Mbps of information contained in a television video signal down to as little as 20 kbps (over 4,000 to 1compression)

and government. Businesses are creating affiliates and subsidiaries around the world. Visual communications systems, such as videoconferencing systems, can improve worker productivity and reduce costs by eliminating or reducing travel, speeding the decision making process by reducing the time needed to exchange information between geographically dispersed work groups and leveraging the use of scarce personnel resources located at a distance from coworkers needing their expertise. Videoconferencing is also enabling programs like distance learning. Lectures can now be remotely attended by students using videoconferencing tools. In the field of medicine, experts can examine patients remotely at a fraction of the costs required by visits.

2.2.2 Major Industry Issues

The important issues affecting the videoconferencing systems and services markets today are the following (Research Studies, August 1996):

- The Telecommunication Act of 1996 was an important step in deregulation of the telephone and cable industry. This act allows long distance carriers like AT&T and MCI to offer local telephone services and the local carriers like baby bells to offer long distance services. Cable providers can also provide telephone services. The act has had a great impact on the pricing structure and access capabilities for high bandwidth transport networks.

- Proliferation of Integrated Services Digital Network (ISDN) and T1 networks have increased the bandwidth available to customers. The cost of leasing a T1 line (bandwidth of 1.45 Mbits/sec) is less than $1000 per month.

- Videoconferencing technology is continuously improving and becoming cheaper. Better compression algorithms and cheaper implementations on silicon have resulted in high quality picture resolution and smoother video. Personal Computer (PC) as a platform for videoconferencing is gaining increasing popularity.

- Convergence of video, audio and document conferencing is making virtual meetings a viable substitute for real meetings.

2.2.3 The Competitive Environment

The emerging videoconferencing systems and service market is volatile and competitive. For years market leaders like Intel, PictureTel and VTEL have dominated this market place. Now attracted by the revenue potential, smaller players are entering the market using the experience they have gained in audio and document conferencing markets. There are about 80 companies selling hardware and/or software videoconferencing solutions.

The market is split into two main segments. The high end room systems or group systems and the desktop or personal videoconferencing systems. Most new companies entering the videoconferencing market are targeting the desktop segment. Desktop videoconferencing is the fastest growing segment of the conferencing market.

New standardized technology is expected to decrease differences in the quality of videoconferencing systems, which will likely make pricing strategies significantly more important for manufacturers. Standard compliance to the H.320 videoconferencing and T.120 dataconferencing recommendations issued by the International Telecommunication Union (ITU) is a major competitive issue for manufacturers. The critical mass of Local Area Networks (LANs) and Wide Area Networks (WANs) capable of video transmission has stimulated the desktop videoconferencing market in 1996. The two new ITU standards, H.323 and H.324, have given a further boost to desktop videoconferencing.

With the new H.324 standard, videoconferencing can be conducted over Plain Old Telephone Lines (POTS). That reduces the cost of a video call to the cost of a traditional phone call. It also brings the possibility of very low cost ($500 or less) personal computer (PC)-based videoconferencing solutions. The level of quality of POTS videoconferencing is below that required for normal business usage, but it is adequate for home use and for business people on the road (to place a video call from a hotel room, for example).

Local Area Networks (LANs), used for data communication among computers in a business office, have experienced a steady increase in speed over the past few years. With faster routers, low-cost 100 Mbps interface cards, and other technologies, most LANs can

easily accommodate the slight additional traffic of video calls. With the H.323 standard, interoperable products for videoconferencing over LANs are being introduced this year. The main advantage of LAN videoconferencing is that it removes the need to bring ISDN connections to every desktop -- it leverages the network cable that is already connected to each PC. With H.323-to-H.320 gateways, videoconferencing systems in a LAN can communicate with any ISDN system.

The Internet has also been emerging lately as a network for videoconferencing, in two forms. First as a way to interconnect geographically-dispersed LANs within the same company (the so-called Intranets)—in such cases usually high-speed portions of the Internet are used, to maintain an adequate bandwidth and quality of service. Second, as a direct connection among any computers or videoconferencing terminals connected to the Internet – in such cases the quality is low, with frequent dropouts in video and audio. Still, Internet videoconferencing allows for the lowest possible connection cost: for the price of a local phone call, long-distance (even international) video calls can be placed (10-K405, March 31, 1997.)

2.3 PictureTel

PictureTel is a market leader in the high end videoconferencing system market. It has a 50% market share in room systems. At the heart of the PictureTel systems is a proprietary technology which enables video compression, audio compression, echo cancellation, automatic volume control, noise suppression, speaker localization for automatic camera positioning, and information sharing protocols/applications.

PictureTel was started as a company in 1984 to provide a software videoconferencing solution over telephone lines. The compression algorithms at that time could not squeeze motion video effectively over the limited bandwidth telephone line. Hence PictureTel transformed itself into a videoconferencing system manufacturer. A lack of high bandwidth infrastructure and high cost limited PictureTel sales in the 1980s. Gradually, as ISDN and other information transmission networks became popular and systems became more affordable, sales began to take off. Figure 2.2 charts PictureTel's annual sales revenue.

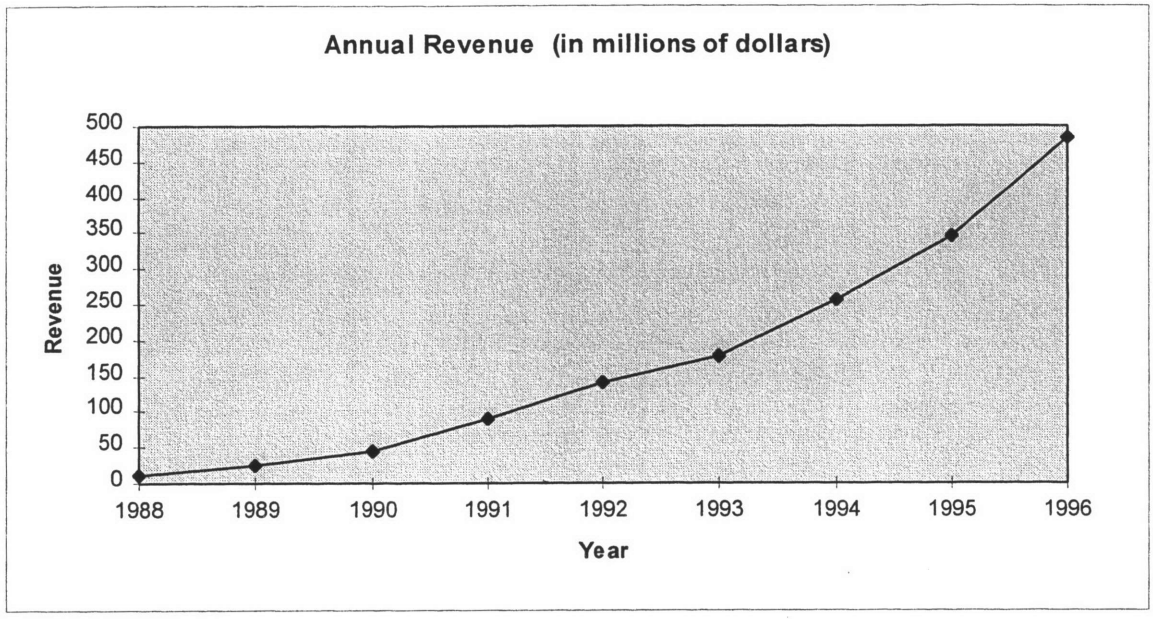


Figure 2.2: PictureTel Annual Sales Revenue

PictureTel now offers three categories of products for videoconferencing. The room or group systems comprise the high end videoconferencing systems and cost upwards of $14,500. Personal or desktop systems are PC based products starting at about $2500. Network systems are dedicated hardware systems that enable multi-point videoconferencing (network systems are needed on top of room systems or desktop systems for conferencing between three or more points). Each of these product lines is administered by a corresponding business division - The Room Systems Division (RSD), the Personal Systems Division (PSD) and the Network Systems Division (NSD) respectively.

In ordering a PictureTel videoconferencing product, a customer is required to specify three line items :

- A **Main System,** consisting of a CODEC and a monitor
- A **Language Kit,** consisting of documentation in a given language, a camera and a key pad controller (key pad controller for room systems only)
- A **Country Kit,** consisting of a power cord with a power plug tailored to the country.

PictureTel' technology allows videoconferencing over X56, RS232, ISDN and T1 networks for the room systems. The room system products can operate at frame rates of 15 or 30 frames/sec. PictureTel caters to Europe, Japan, Asia and Latin America in addition to North America. Some of the countries use the PAL TV standard for signal transmission as opposed to NTSC TV standard. Also, different countries have different AC voltage levels and frequencies. Given the different types of networks, frame rates, TV standards, voltage levels and frequencies a system could have vastly different configurations depending on location and preferences of the end user. In addition, PictureTel offers choices of monitor sizes, high end versus low end camera and a optional second network interface, exploding the number of variations possible within each room system product line.

In the early years sales volume was low and PictureTel catered to many different types of customers to maximize revenue. As volumes increased, the company has found it increasingly difficult to manufacture the vast array of variations within each product line. Managing inventory of raw materials and finished goods, and forecasting the mix of variations within each product line is becoming increasingly difficult. To add to these problems, the product lines in the room systems were not designed for easy configuration on the manufacturing floor. As sales volumes increased, PictureTel's operations became increasingly complicated and three questions were asked as a starting point for addressing this problem

- What configurations do customers actually buy?
- What are the implications of lesser options for lead times of products?
- What are the implications of smaller number of variations for costs and revenues?

Both the room systems and desktop systems were effected by the "too many configurations" problem. However, since room system product lines have the largest number of variations, it was assumed that their analysis should provide us with the necessary insights into the general problem. There are three product lines within the room systems : Concorde, Venue and Swiftsite. Concorde (also called the performance system)

is the top of the line PictureTel offering and is available in over 1,000 variations. Venue (also called the value systems) is the value line in the room systems and is available in over 500 different versions. Swiftsite is a lower end model introduced in 1996. All the analysis was carried out on Concorde and Venue only since little data was available on Swiftsite.

3. Sales Analysis

PictureTel's room systems product lines are offered in a large number of variations. However, some configurations are more popular than others. This chapter analyzes the sales volume of different configurations of the Concorde and the Venue product lines.

3.1 Analysis

The past sales data of the Concorde and Venue systems was used to analyze the demand patterns for the Room systems. In order to remove any seasonality inherent in the buying patterns of the customers, sales data of one year(Q4 '95, Q1'96, Q2'96, Q3'96) was used for the analysis.

The analysis was done in two ways: 1) By sorting total system orders containing country kits and language kits (Complete Systems.) 2) By sorting the main systems without the country and language kits (Main Systems.) The reason for the two analyses was to understand whether PictureTel should offer a bundled system with everything included or let customers pick a Main system, Language kit and Country kit.

The system used for archiving the sales data, Cross Target, did not have adequate analysis tools to sort the sales split information. In particular, the data storage mechanism made it extremely difficult to identify the language kit and the country kits sold with a system. The raw sales data was dumped into text files and computer programs were used to sort and group the sales data into required formats. This data was imported into Excel for a visual inspection of the top selling products. Analysis was done on sales data for each quarter and summary of sales of the four quarters was consolidated into a yearly sales spread sheet to examine trends in sales. The various steps taken to analyze the sales data is outlined at the beginning of Appendix 2.

The output of the analysis is presented in the Consolidated Sales Report section of Appendix 2. For the Complete Concorde system, of all the different variations that sold in a quarter, 18% accounted for 80% of sales. The top sellers did not change much from quarter to quarter. In the analysis of the Main Concorde systems(not containing the

Country kit and Language kit), 24% of the systems made up 80% of the sales. In the case of Complete Venue systems, about 30% of the configurations comprised 80% of the sales. In case of the Main Venue systems, about 26% of configurations sold comprised 80% of the sales. The sales pattern for the Concorde and Venue systems is shown in Figure 3.1 and Figure 3.2 respectively

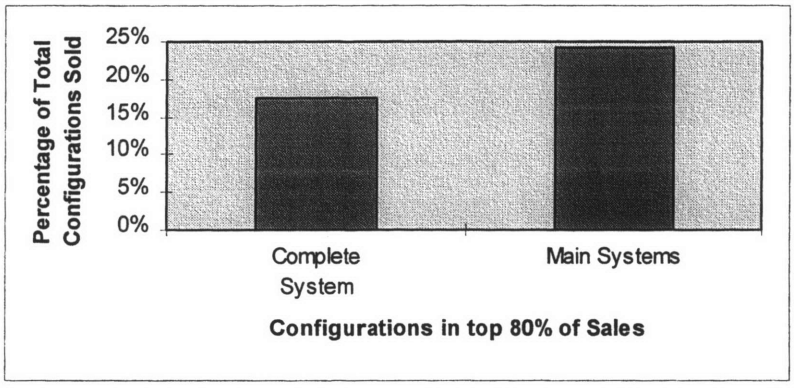


Figure 3.1: Quarterly Sales Pattern of Concorde Systems

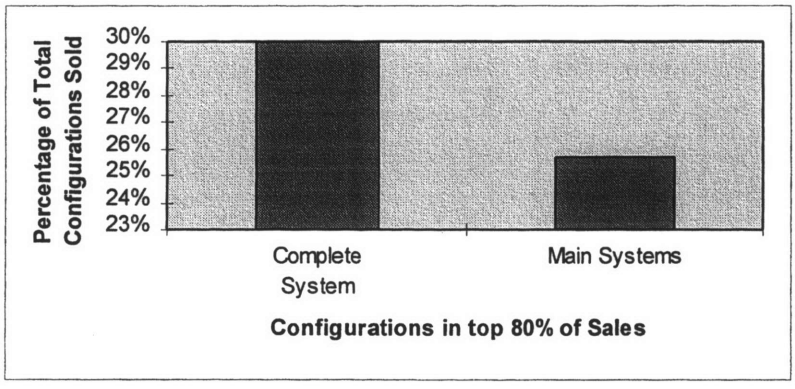


Figure 3.2: Quarterly Sales Pattern of Value Systems

The Sales data clearly indicated that there is some sort of a Pareto effect in sales. A small number of all the configurations sold comprise a large part of the sales volume. Given this phenomenon, PictureTel was wondering if they should be reducing the number of configurations offered.

The answer to this question depended on the impact of a reduced configuration offering on lead times and profits.

4. Lead time Analysis

One of the important reasons for analyzing the slimmer product variation option was to understand its effect on the lead time. There are two types of lead times.

The first type is the lead time seen by the customer. This is the time from the customer ordering the product to the time when the customer receives the product and is called customer lead time. This lead time is more related to customer satisfaction and market responsiveness. It is difficult to place a monetary value on the good will generated by quick turn around time. The second one is the internal lead time seen by PictureTel. This is the time from receiving the raw materials up to the time the company receives payment on shipped products. The dollar amount of cost imposed by this lead time can be calculated as carrying costs. The first type of lead time is dealt with in the current chapter. The latter one is analyzed in Chapter 5 in the carrying cost section.

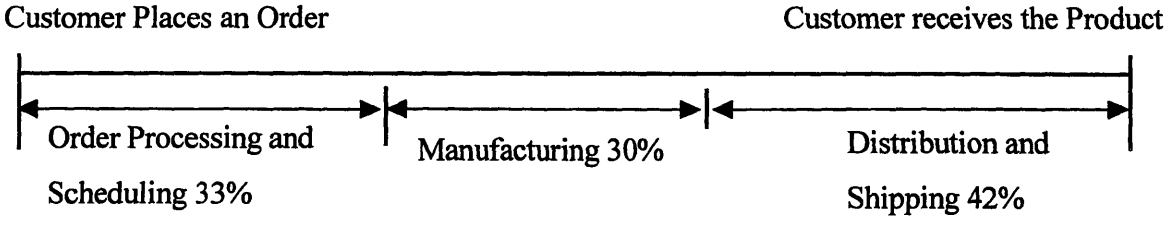


Figure 4.1: Components of Lead Time[1]

4.1 Customer Lead Time

Lead time for a customer is the number of days from the time a customer orders a product to the time a customer receives delivery. There are many components that make up PictureTel's customer lead time. In this section we examine the main components of lead time and how they will be affected by a smaller set of configurations. Figure 4.1 shows the time line for order fulfillment of a typical room system.

[1] Component sizes were obtained from interviews with employees

4.1.1 Components of Lead time

There are three components of customer lead time - 1) Order Processing and Scheduling 2) Manufacturing 3) Distribution and Shipping.

4.1.1.1 Order Processing and Scheduling

Customers order videoconferencing systems directly from PictureTel or through an OEM channel. The order is sent by the sales person through a order entry system to a centralized order processing unit. If the order is coming through an OEM channel it generally goes to the OEM's order processing center and is routed to the PictureTel Order Management group which is responsible for order processing. If the order is coming from the PictureTel sales force, it first goes to a regional center and then to the Order Management group. It is the responsibility of the centralized order processing unit and Order Management group to clean up the order. Order Management also checks the order for compatibility of the various components (line items) and performs credit checks if it is a new customer. Typical errors in orders include omissions of billing or delivery address, incorrect model numbers, omission of country kit and/or language kit (a country kit and a language kit has to be ordered with every system). A significant portion of time is taken up in cleaning an incoming order. This is mainly because of the large number of configurations which causes confusion among consumers and channel sales representatives who are selling other company products along with PictureTel products. Further, the Price book which does not have consistent numbering scheme across product lines contributes to the confusion in the end customers and sales channels.

Once the order is cleaned up it is scheduled. If the product being ordered has a model number in the order management database (called OMAR), it is scheduled by the Order Management group and assigned a ship date. If the product does not have a associated model number in the order management database, the Production Planning group gets involved and schedules the order and assigns a ship date.

Another component feeding into order scheduling is forecasts. At the beginning of every quarter, PictureTel projects the demand for the quarter and hence forecasts the amount of

systems that have to be built each month and hence each day. The demand forecast does not have the configuration mix but just the total number of systems within a product line (e.g. Concorde). If PictureTel plans to build X systems on a given day and Y have been scheduled from the orders received, PictureTel has to forecast the configurations on (X - Y) extra systems it has to build (assuming (X - Y) > 0).

Order processing and scheduling is responsible for 33% of the lead time.

4.1.1.2 Manufacturing

PictureTel manufactures Concorde, the top of the line room system, in house while the Venue system is out sourced. The manufacturing technique used in house by PictureTel is more similar to a cell based manufacturing. Lead time is essentially product assembly and test time. A significant constraint on lead time is components. It is not in-frequent for PictureTel to run out of a particular component. This can hold up a whole batch of systems. In some cases customers get systems with more features than they ask for because a part required for building a system with lesser features is not available. On an average a room system spends 25% of lead time at the manufacturing center.

4.1.1.3 Distribution and Shipping

Once the product is built it is sent to the distribution center which is responsible for shipping the product to the customer. Each order is associated with a ship date (assigned by Order Management group during order processing and scheduling stage) and a customer request date. If a product is at the distribution center before its ship date, it is shipped before the ship date only if the request date is earlier than the ship date. A product may be shipped after its ship date only if it does not arrive at distribution center by the ship date. Such delays are typically caused by shortage of materials at the production center. About 85% of the orders get shipped on or before their scheduled ship date. PictureTel is making efforts to improve this number. A typical room system spends 42% of its lead time in distribution center and in transit to the customer.

4.1.2 Effect of a reduced configuration

Reducing the product options to cater to 80% of the demand results in reduction of product configurations by a factor greater than 20. This should reduce the confusion among customers and make ordering easier. As a result, the number of dirty orders received by Order Management group would decrease and order processing time will reduce consequently. The Order Management group estimated that this would reduce order processing times by about 25-50%.

If the offered variations is a small subset of the current offering, forecasting variation mix becomes much easier. Each order can be shipped directly out of distribution instead of building it on the plant floor first. Manufacturing is no longer in the critical path. The manufacturing component is eliminated in most cases. Hence this component will be reduced by 60-90%[1]. The distribution component does not change due to configuration reduction.

4.2 Results and Sensitivity

From various components in section 4.1.2 we can estimate the range of savings in lead times if product configurations are reduced. Total decrease in lead time ranges between 26-44%. Although this is a fairly tight range, the 24% is calculated from conservative savings estimates in the two components and the 44% falls at the optimistic end of the spectrum. While this improvement in lead time will be tangible to the customer, it is not easy to translate the benefit into dollar terms.

[1] If the configurations are reduced, orders will be shipped directly out of distribution 60-90% of the time. Currently most systems are built to order. Hence the overall savings in manufacturing lead time is 60-90%

5. Revenue and Cost Modeling

This chapter addresses the third question posed in Chapter 1 - What are monetary savings that could be achieved by reducing the number of product variations offered?

There are two sides to economic analysis of any offering, revenue and cost. Since the interest is primarily in the change in revenue and change in cost, it is necessary to only look at the components that change. The major change in costs due to a reduced set of product variation will be in the variable costs. Change in revenue together with change in variable cost can be used to obtain change in profits.

A change in number of configurations will effect the number of systems sold and hence the revenue. To understand the effect of configurations on the number of system sales, a understanding of elasticity of the customer to various product dimensions is necessary. In this case the two important elasticities, price elasticity and feature elasticity of PictureTel's customers were not well known. Most of PictureTel's customers are corporations hence it appears reasonable to assume a low price elasticity. There were two types of features: 1) Features dictated by infrastructural limitations - like availability of only ISDN for communications or 120V power supply at the customer site. 2) Features chosen by customers - like 30 frames per second versus 15 frames per second video rate. While customers are inflexible on features of the former type, they could be probably coaxed with incentives to move to certain features of the second type. At the current stage the percentage of sales PictureTel would lose, by restricting product variations to the ones that comprise 80% of sales volume, appeared to be high. In the worst case it could be as high as 20% of the sales volume.

On the variable cost side the main components are material costs, labor costs, carrying costs, product reconfiguration costs, and product maintenance costs. The contributions from these various components are estimated in the Cost Modeling section in Appendix 1. The analysis is performed on Complete Systems only. Since a Complete system is a Main System with Language kit and Country kit (both the kits cost much lesser than the main system), the results of analysis of Main systems is expected to be similar.

5.1 Components of Cost

5.1.1.1 Material Costs

A large part of the materials is common to most variations in a product line. The common material is bought in bulk at discounts. A slimmer configuration offering will not change the volume and hence prices of common material significantly. Also, in a restricted configuration scenario, the volumes of materials used to make the optional part of the product do not increase significantly to provide PictureTel with purchasing discounts. In other words the sales volume of any particular configuration is not expected to go up significantly in the decreased configuration scenario. Overall, it appears that a cutting down of product configurations will not result in significant savings in material costs.

Material cost is the biggest component of cost of goods sold. Cost of materials is 90% of the cost of goods sold as shown in the Cost Modeling section of Appendix 1.

5.1.1.2 Labor Costs

Each system is associated with labor content at the order processing, and assembly and testing stages. Order processing is described in section 4.1.1.1. Assembly and testing performed on the manufacturing floor is labor intensive. Most of the assembly is done in a batch mode. A batch of systems is laid out on a static assembly line and assembly is carried out. However, the value of total labor content in an assembled system is a small percentage of the cost of goods. Labor is 7-10% of the cost of goods sold as shown in the Cost Modeling section of Appendix 1.

Reducing the number of variations is expected to increase productivity and labor efficiency. Labor savings post variation trimming is estimated between 20-50%.

5.1.1.3 Carrying Costs

Carrying cost is the cost a company incurs as a result of carrying inventory, and customer and supplier payment patterns.

The carrying costs savings from a reduced number of configurations is obtained by analyzing the timeline from purchase of raw materials to the sales of finished goods and the collection of account receivables. The different components of the time line can be calculated as shown in the Internal Lead Time section of Appendix 1.

From the numbers in Appendix 1 the time line is constructed as shown in Figure 5.1

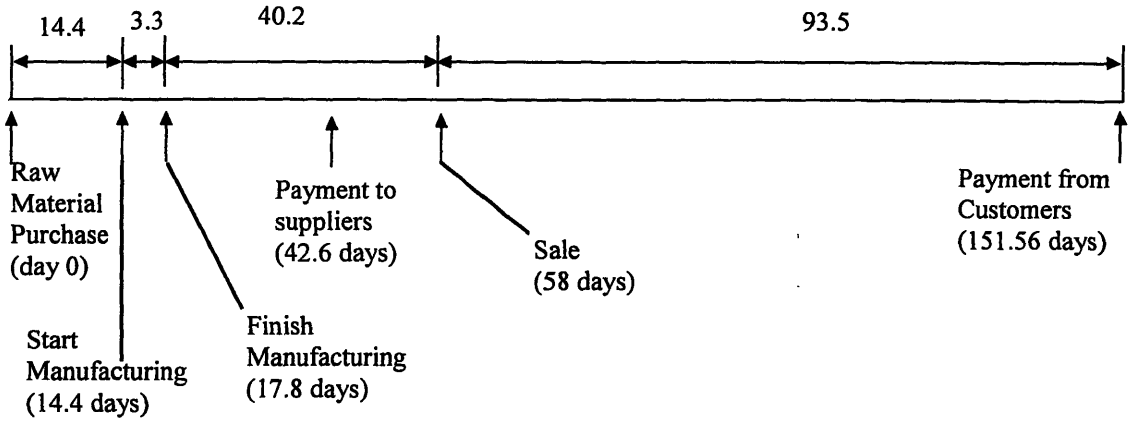


Figure 5.1: Time Line from Purchase of Raw Material to Customer Payment

5.1.1.3.1 Raw Material Inventory

At the front end, raw materials are held as inventory on an average for about 14.4 days. A reduced configuration set will allow PictureTel to operate with lesser inventory at the front end. PictureTel can reduce its inventory by 2-5 days in this scenario.

5.1.1.3.2 Manufacturing

Manufacturing takes 3.3 days on an average. The change over time between different configurations is not very large and hence the estimated savings in manufacturing time due to smaller number of configurations is 0-1 days.

5.1.1.3.3 Finished goods inventory

The finished inventory is in the warehouse for an average of 40 days. Reducing the configurations will let PictureTel reduce this inventory. Inventory can be reduced to 30-35 days resulting in a savings of 5-10 days on this segment of lead time.

5.1.1.3.4 Account Receivable

PictureTel receives payment from its customers three months after the goods are shipped. Two of the reasons for this delay are wrong shipment and short shipment. In the case of a short ship or a wrong ship it may take weeks to resolve the problem and PictureTel pays the cost of carrying capital. Reducing the configurations will chop off 10-20 days of this segment by reducing the number of wrong ships and short ships.

5.1.1.3.5 Cost Savings in Carrying Costs

In all, if PictureTel reduces its configurations, it can shave off 17-36 days of lead time. This would result in lead time reduction and hence carrying cost savings of 11-23.7%.

Table 5.1 presents the carrying cost savings from a streamlined configuration offering.

The current inventory carrying cost is cost of carrying the inventory for	***109 Days*** *(151.6 - 42.6)*
Cost of capital	***15%*** *(Assumption)*
Carrying cost of goods (as a % of cost of goods sold)	***4.5%*** *(109 x 0.15/365)*
Carrying cost savings(as a % of total carrying costs) due to reduced configurations	***11-23.7%*** *(Section 5.1.1.3.5)*
Carrying cost savings(as a % of cost of goods sold) due to reduced configurations	***0.5-1.0%*** *(0.045 x 11%, 0.045 x 23.7%)*

Table 5.1: Carrying cost estimation

5.1.1.4 Product Re-configuration Costs

The company is reasonably accurate in forecasting the total number of systems demanded in each product category. However, the large product variety has resulted in a great difficulty in forecasting the variety mix demanded each quarter. This means that

PictureTel has to pull finished goods from its inventory to shop floor for rework. Rework can be reduced by increasing inventories and beefing up buffer stock. However, when the number of configurations is large, it less expensive to re-work systems than to solve the problem by increasing the inventory.

Re-configuration costs was found to be nearly 1% of the cost of goods sold as shown in Cost Modeling section of Appendix 1. It is estimated that this cost can be reduced by 10-50% if the product line is trimmed.

5.1.1.5 Wrong Shipment and Short Shipment Costs

As mentioned in chapter 2, PictureTel sells products directly and through OEM channels. An order can pass through three to four different people before reaching the shop floor or distribution center. Given the large variety of configurations and a slightly complicated product numbering scheme there are wrong shipments. Also, the large number of configurations result in large number of non standard items, which are either packaged on the shop floor or picked from distribution. The result can be failure to ship a component with the system resulting in a short ship or shipping a component different from the one ordered resulting in wrong ship.

The cost of re shipping wrong shipped or short shipped components is about 0.5% of the cost of goods sold. It is grossly estimated that there will be about 10-50% savings in this cost if the product configurations is trimmed. The bigger problem with wrong ship and short ship however is the increase in lead time for customer and delay in Customer payment. The costs resulting from these longer lead times is factored into the carrying cost component.

5.1.1.6 Product maintenance Cost

Product structure for every configuration of a product is maintained in a database. This is typically a bill of material(BOM). A large number of configurations means a large amount of data to be maintained. At a system level, this can mean investment in larger database systems, more hard disks and sophisticated tracking software. On the people side it can mean large time required to maintain the high variety. For example a

ECO(Engineering Change Order) will have to be applied to all or some product varieties each time there is a design change. The person in charge of ECO changes will have to understand how many of the configurations are effected by the ECO and then make changes to the BOMs through a semi-automatic process.

This cost of BOM maintenance turns out to be very small for PictureTel. It is about 0.01% of cost of goods sold. Savings from reduced product offering is estimated to be 50-80%

5.2 Results of Analysis

The cost analysis is shown in Cost Modeling section of Appendix 1. Profit After Variable Costs (PAVC)[1] is calculated for the existing configuration case and the more restricted variety case. Revenues are assumed to be the same in both cases. In the second case PAVC improved by only 1-4%. Now consider a third case where sales shrink by 1-4% after restricting configurations- revenues, TVC and hence PAVC would fall by 1-4% over the corresponding values in the second case. This would make the PAVC in third case equal to the corresponding value in the first case. This implies that streamlining would have to result in loss of not more than 1-4% of the existing sales if PictureTel has to keep its profits (PAVC) from dipping. Though the results may seem surprising at first, closer observation gives us reasons for such small profit improvement. There are two fundamental reasons for the small improvement.

First, from section 5.1.1.1 we see that material cost is the major portion of the total cost of a system. Material costs constitute about 85% of TVC (90% of Cost of Goods Sold). Streamlining product offering does not result in a savings in material costs. Reducing product variations can result only in a savings in operational (non material TVC) costs. However, a 50% savings in operational costs means only a 7.5% savings in TVC. This is not a huge cost savings.

[1] Profit After Variable Costs (PAVC) = Revenues - Total Variable Costs (TVC)

Second, PictureTel has PAVC margins greater than 50%. The marginal profits in selling PictureTel systems to the 20% of customers, who ask for the not so popular 80% of configurations sold, is even higher.

Figure 5.2 illustrates the result of the two facts presented above. We see that any savings in operational costs as a result of the trimming is much smaller compared to the PAVC profit on a system. Cost modeling section in Appendix 1 presents the numbers relevant to

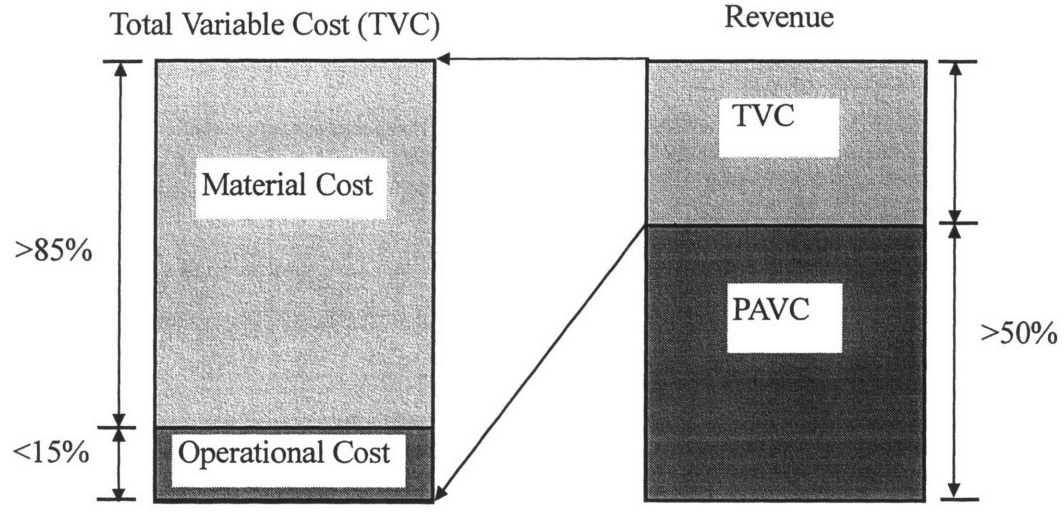


Figure 5.2: Illustration of Costs and Margins

the different components in the figure. Savings as a percentage of PAVC (Profits After Variable Costs) is less than 4%. If the streamlining results in a loss of more than 4% of sales, PictureTel's profits will fall.

5.3 Sensitivity

In the cost analysis, assumptions and estimates were used to fill in the gaps between partially available information. This section examines the sensitivity of the results to these assumptions and estimates.

The cost of materials is a large component of the cost. Any uncertainty in material cost estimates can have a significant effect on cost analysis. Since we know the current average material costs and since the impact of configuration trimming on material costs is negligible, material cost estimates in the post trimming scenario are reasonably accurate.

The labor content in a finished goods was obtained from the finance department of operations. The finance department estimates the labor content in a product by measuring the total output per quarter and the total labor dollars used per quarter. Since the labor cost is a small part of the total cost, inaccuracies in estimates of labor cost savings are dampened in the overall cost savings.

In the case of carrying costs, the time line was constructed from a snapshot of financial data at the end of June 1996. Hence, the time line may not reflect average numbers during a quarter. In particular since PictureTel sells a large number of systems at the end of a quarter, the account receivable and hence the lag time shown in the time line between a customer purchase and payment may be greater than average. Large orders at the end of a quarter may also reduce pipeline inventory at the end of the quarter resulting in smaller than average manufacturing lead times. Cost of capital is assumed to be 15%.

Relative (to cost of goods sold) costs of Short ship, Wrong ship, Re configuration and Product maintenance were found by using the respective cost numbers for the third quarter. The percentages were expected to remain same from quarter to quarter over a year's horizon.

It is worth noting that the non material variable cost of a system was less than 15% of TVC (Total Variable Cost). The material component which was 85% of TVC is estimated with reasonable accuracy. Even if the non material cost estimates was off by 50%, total costs would be different only by about 7.5%. Except material cost savings, all other cost savings were either estimates by the author or data gathered from informal consultation with various employees. However, since these components comprise only 15% of TVC, any error in savings estimates will be significantly small percentage of TVC and hence PAVC. The results would therefore not change drastically.

6. Recommendations

This chapter ties together the results from the analyses in the previous chapters and presents recommendations for the future.

6.1 Conclusions

A summary of important results from chapter 3 to chapter 5 is shown in Table 6.1.

Percentage of total configurations in the top 80% of sales (Complete systems)	18-30%
Customer lead time reduction due to reduced configurations	26-44%
Cost reduction due to reduced configurations (as a percentage of PAVC)	less than 4%

Table 6.1: Summary of results from analysis

As noted in chapter 5 it is not easy to understand the amount of sales PictureTel will lose if it migrates to a more limited configuration offering. Corporate customers are likely to be more feature elastic than price elastic. Hence, there is a chance of losing the large part of the 20% of the sales if PictureTel trims the number of configurations. From Table 6.1 we can see that the cost reduction due to product trimming is less than 4% of the PAVC (Profit After Variable Costs). This means that PictureTel can afford to lose no more than roughly 4% of its sales due to configuration reduction if its profits are not to be effected. It is difficult to understand the impact of a 26-44% lead time reduction on customer good will and hence product sales. Given the feature elasticity of the customers, PictureTel will probably lose more than 4% of its sales due to trimming in spite of the reduced lead time.

6.2 Recommendations

PictureTel should not cut down the number of configurations immediately, since this action would depress profits. However, in the future two things will happen. First, cost of materials will fall. This is evidenced by the rapid fall in prices of semi-conductor

electronic components and a large part of material costs in a videoconferencing system is semi-conductor component cost. Second, competition will increase as more players enter the market.

As competition increases, PictureTel's profit margins will come down. As margins fall and material costs decrease, the economics of the model presented in Chapter 5 will change and a restricted configuration offering will make more sense. Further, this can happen in 2-3 years. This would mean that PictureTel should start shepherding its customers to a popular subset of its current product offering and when the time is right, restrict its offering to a more manageable and economic set of product variations. Customers can be moved towards certain configurations by providing price and lead time incentives. In order to accomplish this goal, PictureTel has to do the following

1. Monitor sales of each product line to see which options and configurations are selling. This should enable PictureTel to understand what the customers want and also monitor the effectiveness of any campaign to shepherd customers. It should also aid decisions on options and configurations for new products. Appendix 2 gives a step by step procedure and software code necessary to monitor the sales split.
2. Visit lead time and cost analysis model (presented in Appendix 1) of a restricted product offering at regular intervals.

Cost analysis and customer buying patterns should help product managers trim the offering resulting in lower costs and smaller lead times.

7. Future Options

While the bundling strategy has worked successfully in automobiles and some other products, it relies on the assumptions that customers can be segmented into a few groups and one product bundle will satisfy each group. The videoconferencing market may not converge to a few dominant configurations. It may become increasingly non-homogenous and the bundling strategy can turn out to be strategic dis-advantage. This chapter deals with options like mass customization and platform designs which PictureTel can use to tackle a heterogeneous market scenario. The last section enumerates some larger strategic changes PictureTel can make to deal with the coming competition.

7.1 Mass Customization

In the videoconferencing market, customers on the one hand are demanding that their orders be fulfilled ever more quickly and on the other hand, they are demanding highly customized products and services. At a basic level the two demands seem to pull manufacturers in conflicting directions.

Hewlett Packard was confronted with similar pressures in many of its businesses, including computers, printers, and medical products. It has proved that companies indeed can deliver customized products at a low cost and with smaller lead times. Some companies in industries like apparel, paint and consumer electronics have had similar success: they have dramatically increased their product variety, slashed the time they require to fulfill customers' orders, and reduced costs (Feitzinger and Lee, 1997.) This concept of customizing a product to the preferences of each customer in a large heterogeneous market is called *mass customization.*

Some companies have mass customized on the other hand and seen their costs soar out of control. The key to mass customization is not to take a piecemeal approach. Instead, companies must rethink and integrate the designs of their products, and processes used to make and deliver those products, and the configuration of the entire supply chain.

Mass customization can be performed at one or more of the links in a organization's value chain shown in Figure 7.1 (Pine, 1993, P. 173.)

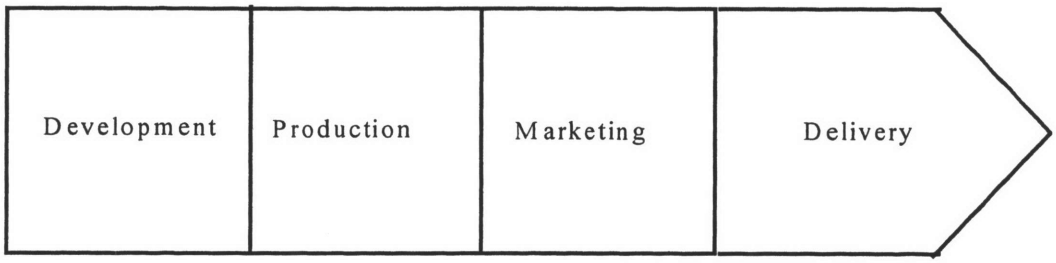


Figure 7.1: Key Links in an Organization's Value Chain

PictureTel can customize at various links to achieve different mass customization effects. Some of the possible ways are outlined in the following sections.

7.1.1 Customize Products at a Later Stage

Videoconferencing products can be customized by people in marketing and distribution. This method is implemented in the last two links of the value chain (See Figure 7.2) and the company produces either standardized products or a smaller variety of products on the

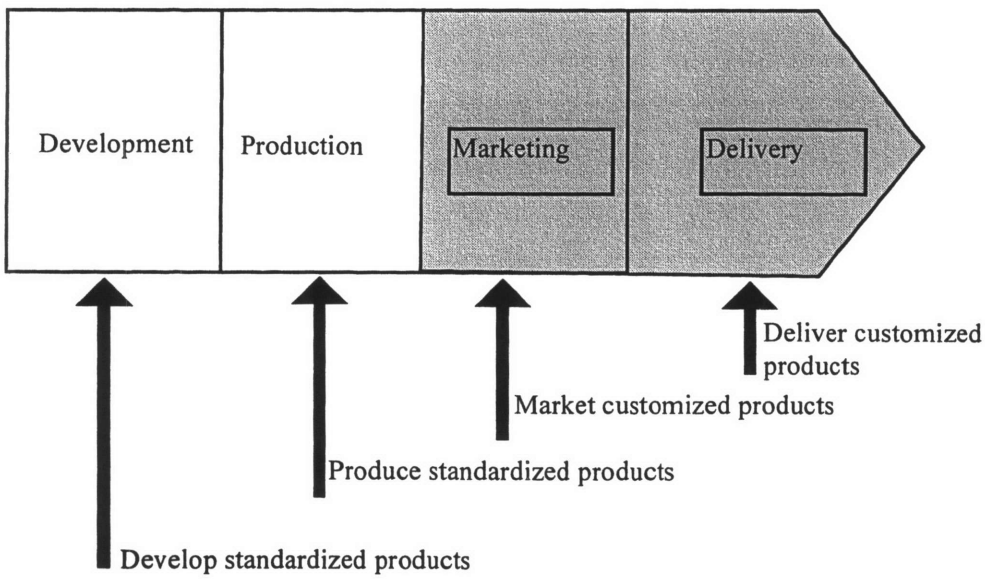


Figure 7.2: Changes in Values Chain to Customize Products at Later Stages

manufacturing floor.

PictureTel can customize products in the field or at the distribution center. The field application engineers can configure certain features at the customer site. These include software modules that can be installed based on the infrastructure available at the customer site and the features demanded by PictureTel customers. PictureTel currently does not configure anything in the field. This form of customization would need a trained set of field applications engineers. Configuring in the field may have implications for testing. The person configuring the system in the field may have to run diagnostics on the system after feature installation.

PictureTel can follow in HP's footsteps and perform part of its assembly at the distribution sites. HP manufactures printers in Singapore for the European and Asian markets. The company opted to customize some printers at its local distribution centers rather than at its factories. For example, instead of customizing the DeskJets at its factory in Singapore before shipping them to Europe, HP has its European distribution center near Stuttgart, Germany perform this job. The company therefore designed the printer with country specific external power supply that the customer plugs in when setting up the printer. The distribution not only customizes the product but also purchases the materials that differentiate it (power supplies, packaging, and manuals). As a result of this design, manufacturing costs are slightly higher than when the factories customized the printers, but the total of manufacturing, shipping, and inventory costs dropped by 25%. PictureTel faces similar issues for power supplies, OEM sales, and manuals. The only possible difference is that HP DeskJet sales volumes are higher than current PictureTel room system sales. However, postponing the customizable part of manufacturing may still be a good economic proposition for PictureTel. This set up will need better infrastructure than PictureTel currently has in its distribution centers. The distribution centers will need assembly and testing capabilities (Feitzinger and Lee, 1997.)

7.1.2 Create Customizable Products

The opposite tactic of customizing products in the delivery function is to develop products that are customizable at the customer site. Customization is performed by the

customer or automatically chosen by the system based on other configurations. The effects of this technique on the organization's value chain are shown in Figure 7.3.

PictureTel can load in the same software module irrespective of the features contained in the system. At the customer site, once the system is plugged in, the software can run diagnostics to figure out system configuration and use the proper software modules for appropriate functioning of the system.

In cases where options like interfaces are governed by infrastructural standards in a

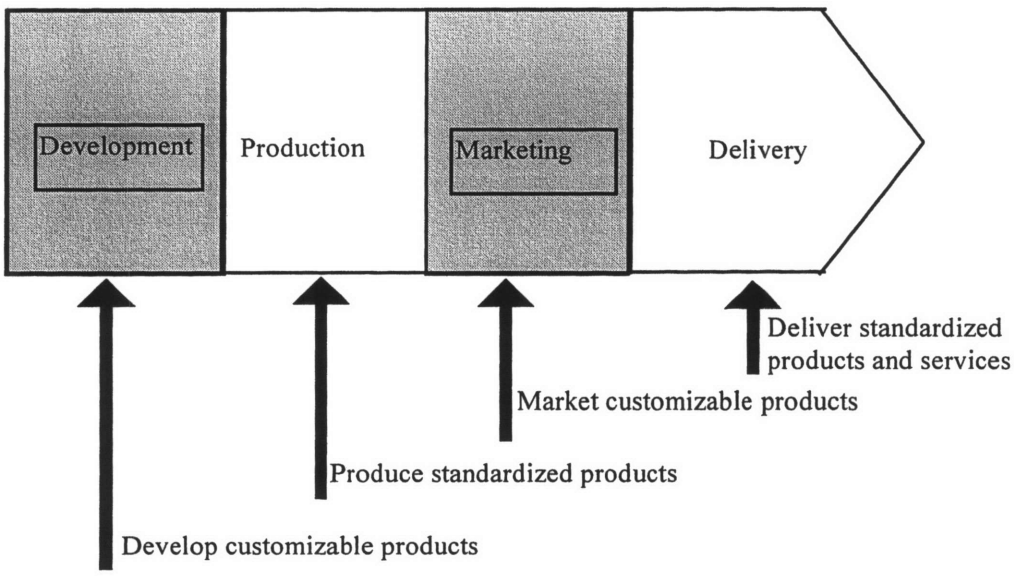


Figure 7.3: Changes in Values Chain to Create Customizable Products

country, it may be economical to offer a multi-interface system instead of creating system with different interface options. For example, most country kits consist of just a power cord. Plug-in sockets have different physical interfaces in different countries. Currently, PictureTel has a large number of country kits to accommodate this infrastructural difference. A possible solution to eliminate the country kit would be to offer one standard power cord and a set of power plug adapters with each system. The customer in the destination country can slip the proper adapter over the plug of the power cord to ensure infrastructural compatibility. The inclusion of extra adapters should cost only a few more dollars but save costs in order processing, packaging, inventory and reduce stock out costs.

Standardization of components can be another way to build in customization. HP has successfully implemented a standardization strategy for the LaserJet printer that sells in Europe and North America. A partner in Japan makes the printer's core engine, which then is shipped by sea to the two markets. Before HP and its partner designed the LaserJet for mass customization, the printer had a dedicated power supply of 110 volts and 220 volts, which forced the company to differentiate it by end-customer market as soon as the partner started building the product. Under the improved design, a power supply that works in all countries is built into the product. This universal power supply prevents HP from committing a system to a country during manufacturing. HP was able to reduce the total costs of manufacturing, stocking, and delivery of the finished product to the customer by 5% every year (Feitzinger and Lee, 1997.)

In general, since standardized components will increase cost of materials, PictureTel should carefully asses the benefits of using such components against the added costs. The value of common components depends on the uncertainty in product demand across PictureTel's geographical markets, the lead time to replenish its stock parts, the length of the product's life cycle, and cost of shipping finished product. As uncertainty, lead time, and inventory and stock-out costs increase, so do the benefits of standardization. HP found that forecasting the mix of options that customers want is most difficult at the beginning and end of a product's life cycle (Feitzinger and Lee, 1997.) This is true to a large extent for PictureTel products. This factor coupled with the ever shortening life cycle for video conferencing systems increases average uncertainty during the entire product life cycle and thus the benefits of standardization.

PictureTel already allows some user configurable options like storing most frequently dialed videoconferencing numbers in speed dial and storing user selected camera presets at the beginning of a conferencing session so that the camera can move from one preset position to another during the session, with the touch of a button.

7.1.3 Modularize Components to Customize End Products

The best method for achieving mass customization - minimizing costs while maximizing customization - is by creating modular components that can be configured into a wide

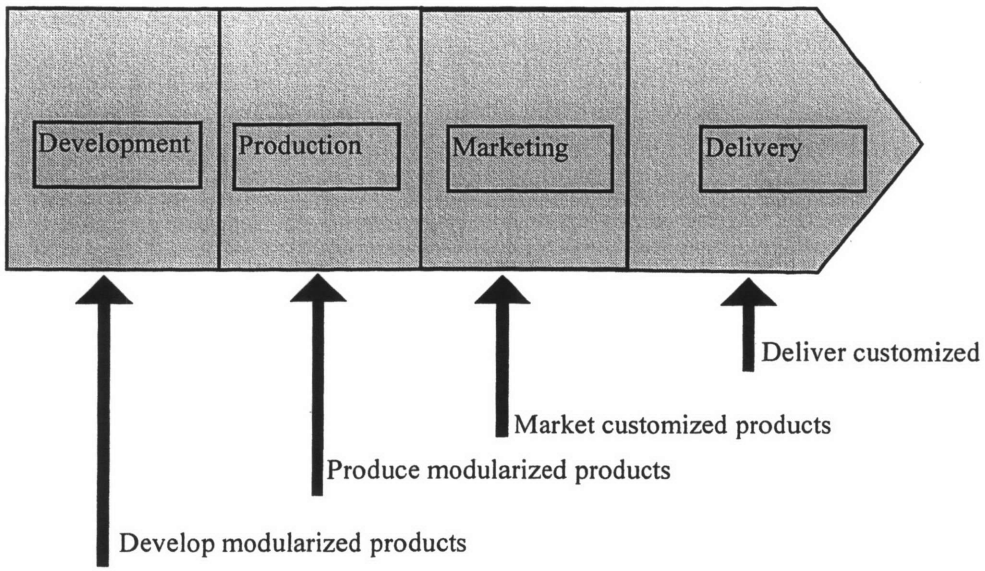
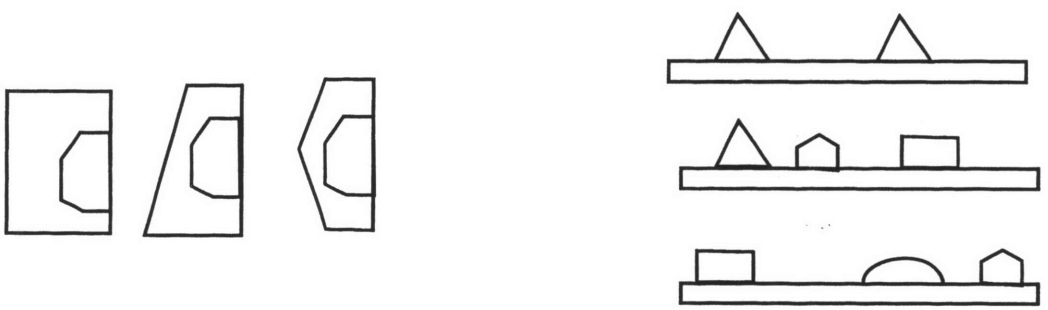


Figure 7.4: Changes in Value Chain to Modularize Components

variety of end products and services. Economies of scale are gained through the components rather than the products; economies of scope are gained by using the modular components over and over in different products; and customization is obtained by the myriad products that can be customized easily. As shown in Figure 7.4, this affects every link in the organization



Component sharing
Modularity

Bus Modularity

Figure 7.5: Two Types of Modularity for Mass Customization of Products

There are different types of modularity. Karl Ulrich, professor of management at MIT, has done a lot of work of modularity of products. In a paper he co-authored with Prof.

Karen Tung (Ulrich and Tung, Sep 1991), they have identified at least six types of modularity. Two of those types will be discussed here in the context of PictureTel. Figure 7.5 shows two types of modularities, Component sharing modularity and Bus modularity. PictureTel can use these two types of modularity to deliver mass customized products in a cost effective manner to its customers.

7.1.3.1 Component Sharing Modularity

In component sharing modularity, the same component is used across multiple products to provide economies of scope. Black and Decker illustrates this well. It completely redesigned its power tool product lines - twice- to take advantage of component-sharing modularity to greatly reduce costs while providing more variety and speedier product development.

PictureTel could use component sharing modularity in number of ways. The hardware that compresses and decompresses the pictures at 30 frames per second can be made into a module which can be reused in a different product lines. The software that runs on the systems can be modularized and used in different module combination across the product lines and configurations.

7.1.3.2 Bus Modularity

This type of modularity uses a standard structure that can attach a number of different kinds of components. Computers and other electronic equipment use this modularity in the form of back plane buses which forms the primary pathway for information transfer between memory, processing units, disk drives, and other components.

PictureTel can use this type of modularity to standardize a communication bus across its product lines. The different components can be plugged into this bus to create a variety of customized products. Such a bus will also allow a customer to scale his/her system easily by plugging and unplugging a few components.

7.2 Product Renewal through Platform designs

When companies design new products one product at a time, the single products must compete for resources against other projects in the corporation's portfolio. The lead times to product development are significant since each product will have little in common with the other products. Economies of scope may not be possible if each product uses different components for the same purpose. Given this scenario it may be better to build an entire family of products that leverage a common market understanding, common product technologies, and a common set of highly automated production processes. The common core underlying any such family is termed as the *product platform*. The platform concept overlaps with the modular design concepts. Product platform could be used to lower cost of development and production, decrease lead times and increase product variety. In other words, a well designed platform should enable mass customization.

7.2.1 Thought Architecture for Effective Product Renewal

In an age where product life cycles are rapidly shrinking, fast and economic product renewal is becoming very important for a company's success. Platforms by themselves will not solve the product renewal problem. Effective product renewal is not possible by taking a piecemeal approach. Instead a systems approach is necessary. Functional groups like engineering manufacturing and marketing should work together and the company should adopt a long term horizon. Mark Meyer and Al Lehnerd (Meyer and Lehnerd, 1997, P. 15) outline five principles that comprise the thought architecture for effective product renewal.

7.2.1.1 Product Family Planning and Platforms

A company should plan and manage on the basis of the product family. Product family principle is being used by some of today's leading companies. Intel's dominant share of the microprocessor market has grown through successive generations of chip designs, each more powerful than the last. Each basic design, be it the 8086 developed and marketed almost twenty years ago or the Pentium Pro marketed today, has been tailored to provide different performances at different price points.

PictureTel has adopted a product platform approach. The Concorde systems and Venue systems are two platforms in the Room Systems. Each of these platforms can be configured in myriad ways to cater to the tastes and price points of different customers

7.2.1.2 Simultaneous Design for Production

Simultaneous design for production is the early and continuous integration of product design with manufacturing design. Manufacturing design is the design of manufacturing systems and processes.

At PictureTel manufacturing issues have traditionally been given lesser emphasis during product design. Increasingly this is becoming an issue and reflecting in in-efficiencies on the manufacturing floor and higher cost of production. A tighter integration between the two functions is necessary to reduce cost of manufacturing, increase quality, and decrease production cycle time.

7.2.1.3 Global Product Design and Market Development

Development teams must have a global perspective for sourcing technology for new products. Teams must research customer needs and preferences, distribution channels, support requirements, and technical and product safety requirements beyond domestic borders. Failure to perform such due diligence can either lock the product out of certain markets or increase the costs drastically at a later date.

PictureTel uses a cross functional team in product design. Marketing, Operations, Service, Engineering and Finance are involved in product design. However, there is no solid process to guide the cross functional team. Another problem is that all groups are not involved at the early stages. A clearly defined process together with proper accountability is important for the success of a cross functional design team.

Political and geographic boundaries impose certain restriction on PictureTel products. For example, US government forbids the export of any product containing strong encryption technology to foreign countries. However, since the encryption module is present directly on the main printed circuit board of a PictureTel product, soldering the encryption chips on to the main board, a task performed in the early manufacturing stages, constrains the

destination of the system to United States. A better design, accounting for the government policies, may have been a plug-in type of a encryption module inserted at later stages of assembly, or at distribution centers.

7.2.1.4 Discover Latent, Unperceived Customer Needs

Good market research can identify the perceived needs of the customers. Most companies readily understand how to do this type of research. Far more difficult, but more powerful as a source of competitive advantage, is the ability to identify needs that customers have not yet learned to articulate.

This principle is very important to PictureTel. The market for videoconferencing equipment and service is still nascent. A clear dominant design has not emerged yet since the market is still undergoing dramatic changes. The key to success of a videoconferencing company could be the recognition of customer preferences before they crystallize in the market place. PictureTel has to refine its market research skills and constantly keep tuned into the customer base to capitalize on the latent opportunities.

7.2.1.5 Elegance in Design

The norm in the most industries is to add functionality to existing designs. If a product is selling, the company will come up with a "new and improved" version by adding bells and whistles. Soon the product becomes difficult to use. Customers' resistance to complexity is observable in the case of Personal Organizers and VCRs. Simplicity, on the other hand, is a virtue. And simplicity in product design can often be attained through modular construction.

PictureTel has added features to its Room Systems products over the last few years. This has resulted in the in-evitable complexity and difficulties for users. While PictureTel has attempted to tackle this issue by designing the wireless remote control panel with text and icons to create an easier interface, the system operation is still far from intuitive. A more modular design and a consistent look and feel of interface across product lines may result in economies of scope and a customer lock in as they upgrade or buy additional videoconferencing equipment.

7.2.2 Framework for Managing the Evolution of a Product Family

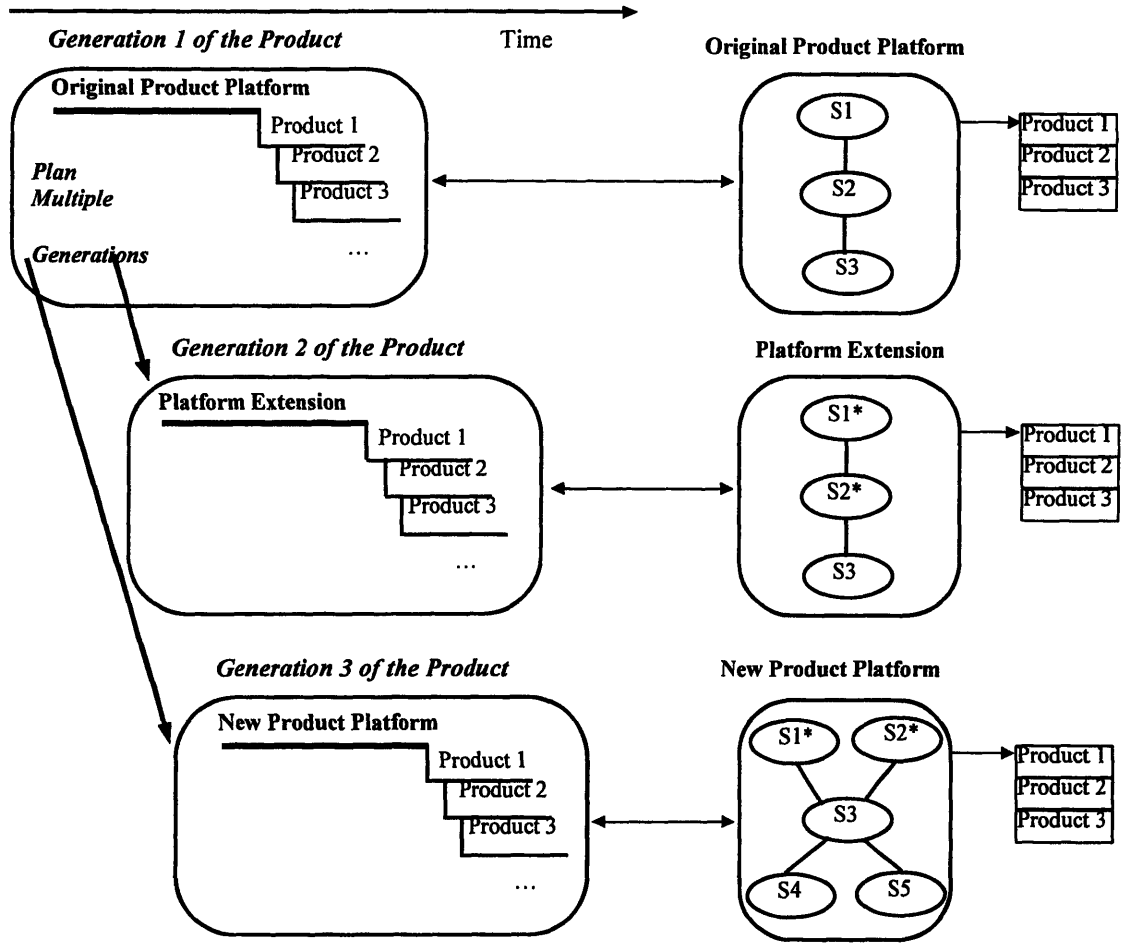


Figure 7.6: Product Family Evolution, Platform Renewal, and New Product Creation

Figure 7.6 shows a general framework (Meyer and Lehnerd, 1997, P. 36,42.) for considering the evolution of a product family. This pattern of evolution illustrates how development work that focuses resources on product platform can carry a company into the future and across transitions in technology and market needs. The figure represents a single product family starting with the initial development of a product platform, followed by successive major enhancements to the core product and process technology of that platform, with derivative product development within each generation

The original product platform is a set of subsystems and interfaces serving as a common architecture for creating derivative products. In Figure 7.6 S1, S2 and S3 are subsystems. In a platform extension, the number and type of subsystems and interfaces remain

constant but one or more are substantially improved with new technology. A new product platform is a new architecture, i.e., a new combination of sub-systems and interfaces. Some subsystems and interfaces from prior generations may be carried forward and combined with new subsystems and interfaces in the new composite platform design.

By following a platform strategy outlined above, PictureTel can reduce the design cycle time and costs since derivative products can be created at incremental cost relative to the platform. Since products are based on a platform, manufacturing can be structured and optimized around platforms reducing manufacturing lead time. Hence, a platform based design may enable economic mass customization for PictureTel.

7.3 Strategic Options

The options enumerated in previous sections dealt with ways to effectively deal with short lead times and heterogeneous market for a given product vision. This section steps one level up the ladder of abstraction to examine the product vision itself.

As mentioned in Chapter 2 the videoconferencing industry is at an important juncture. With the tremendous progress in cost/performance of various technologies, a change in industry structure appears likely in the near future. PictureTel may have to consider larger strategic changes to align itself with the changing conditions. In this section two such options are considered

7.3.1 The "Ferrari" Option

The coming competition is likely to be based on price and features. In such a case, PictureTel can choose to compete just on features. If PictureTel does not want to get caught up in a competitive low margin business it can migrate to better technology and serve higher end markets where the margins are high and competition is more in features and technology and not in costs.

However, this can be a risky strategy if PictureTel fails to maintain the technology edge, or technology becomes standardized or the low end competitors gradually start closing the gap in technology and features. This is happening in the desktop computer industry

right now. The IBM clone (PC) performance is getting closer and closer to that of a workstation. It is causing problems for workstation players like Sun and Silicon Graphics. The story of VCR industry in America is similar. The Japanese came in at the lower end with low quality and low cost. The American manufacturers decided to concentrate on the high quality high cost niche leaving the lower end to the Japanese. Over time, the Japanese manufacturers improved their quality and technology and pushed the American manufacturers into a smaller and smaller corner until they capitulated. The "concentrate on high end" strategy hence appears to be fraught with risks.

7.3.2 The "Microsoft" Option

The other option for PictureTel is to out source more and more of its hardware design and manufacturing and focus on software.

The entire paradigm of videoconferencing can change in the future presenting a great threat to PictureTel's current business model. A shake up in the word processing industry in the late 1980s bankrupted the then leader Wang computers. Wang made the best word processing machines in the world. However, in the late 1980s the very structure of the computer industry was changing. Word processors were introduced as just another application software on general purpose PCs. With the increase in performance of the PCs the quality and capability of the word processing software improved to rival that of the dedicated machines like Wang and eventually drove the dedicated machines out of business. A similar thing may happen to videoconferencing. It can become just another application of a PC or a telephone. The new MMX technology introduced by Intel is a step in that direction. Such structural changes in the industry have profound implications for PictureTel's business model and concentration of resources.

If videoconferencing will eventually become a part of the PC, PictureTel may be better off focusing on the software, compression and communication algorithms. Since PictureTel's crown jewels are these algorithms, it can concentrate on developing the software to implement its algorithms and license the software to hardware manufacturers. In the best case PictureTel can become the Microsoft of videoconferencing.

Appendix 1

Selected Financial Data

The following tables show the Balance sheet, Income statement and Inventory position for the six months ending June 29, 1996 (10-K405, March 31,1997.)

Balance sheet (June 29 1996, in 000s)					
Assets			*Liabilities*		
Cash and Cash Equivalents	$	45,490	Short-term borrowings	$	527
Marketable securities	$	15,478	Account Payable	$	26,759
Account Receivable	$	113,311	Accrued compensation	$	7,654
Inventories(Note 2)	$	36,390	Accrued expenses	$	20,836
Deferred taxes, net	$	6,561	Current Portion of Capital lease	$	2,172
Other Current Assets	$	7,311	Deferred Revenue	$	18,442
Total Current Assets	$	224,541	Total Current Liabilites	$	76,390
Marketable Securities	$	36,273	Long-term borrowings	$	10,015
Deferred taxes, net	$	6,000			
Property and equipment, net	$	35,711	Captial lease obligations	$	1,411
Capitalized software costs	$	6,127			
Other Assets	$	6,955	Stock holders equity	$	227,791
Total Assets	$	315,607	Total Liabilities and stock holders equity	$	315,607

Income Statement (six months ended June 29 1996, in 000s)		
Revenues	$	221,083
Cost of Sales	$	114,452
Gross Margin	$	106,631
Operating Expenses		
SG&A	$	58,815
Research and Development	$	27,965
Total Operating expense	$	86,780
Income from Operations	$	19,851
Interest Income, net	$	2,179
Other Income(expense), net	$	1,814
Income before taxes	$	23,844
Provision for Income taxes	$	7,887
Net Income	$	15,957

Note 2	
Inventory consist of the following(in thousands)	
	29-Jun-96
Purchased Parts	$ 9,061
Work in Process	$ 2,098
Finished Goods	$ 25,231
	$ 36,390

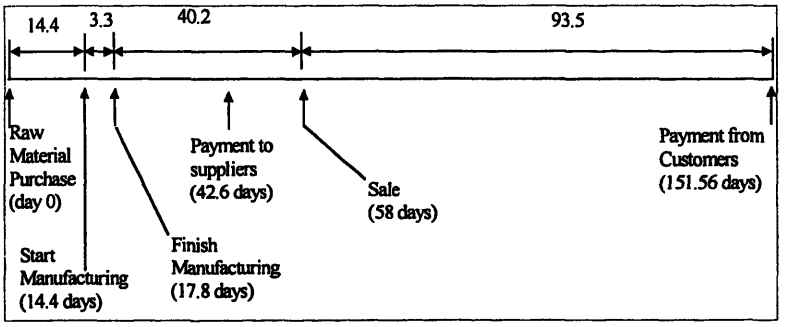
Internal Lead Time

This section constructs the time line from the purchase of raw materials by PictureTel to the sale of finished goods and collection of receivables(Palepu, Bernard, and Healy, 1996, P. 4-11,13.) The data used in the calculations is obtained from the section Selected Financial Data in Appendix 1. The timeline is used in calculating carrying costs in Chapter 5.

Internal Lead Time

Raw material gets into manufacturing pipeline after an average of	$\frac{\text{Purcahsed Parts}}{\text{Cost of Goods Sold}} X \frac{365}{2}$	=	14.45 days
The average time taken to convert raw materials to finished goods	$\frac{\text{Work in Process}}{\text{Cost of Goods Sold}} X \frac{365}{2}$	=	3.35 days
The average time a finsished goods spend in inventory	$\frac{\text{Finished Goods Inventory}}{\text{Cost of Goods Sold}} X \frac{365}{2}$	=	40.23 days
Average time between sale of goods and customer payment	$\frac{\text{Accounts Receivable}}{\text{Revenues}} X \frac{365}{2}$	=	93.54 days
Average number of days to convert Raw materials to finished goods		=	151.56 days

Average time between raw material purchase and supplier payment	$\frac{\text{Accounts Payable}}{\text{Cost of Goods}} X \frac{365}{2}$	42.67 days



Time Line for conversion of raw material to finished goods.

Cost Modeling

This section presents the Excel spread sheet used to model costs in Chapter 5. The model can be used with both Concorde and Venue Systems' financial data.

The revenue, cost of material, and labor cost data were obtained from the finance department of the operations division. The carrying cost is obtained as a percentage of cost of goods sold from Table 5.1. Short ship and wrong ship costs are tracked by PictureTel operations department every quarter. Product Maintenance cost is an estimate of labor cost to maintain the Bill of Materials (BOM). It was estimated based on average salary paid to a person in charge of product maintenance. The sum of cost of materials, labor, carrying, reconfiguration, short ship and wrong ship, and product maintenance is called Total Variable Cost (TVC). The difference of Revenues and TVC is called Profit After Variable Costs (PAVC). The difference of PAVC and fixed cost is Profit Before Tax for PictureTel. Since the Fixed Cost is not effected by reduction of configurations, it is not a part of the analysis.

Current cost calculation column shows the current costs (actual and estimates) for the third quarter of 1996. The next column calculates the costs based on savings estimates in Chapter 5.

$$\text{Savings as a percentage of PAVC} = \frac{\text{PAVC including cost savings - Original PAVC}}{\text{Revenues}}$$

Confidential dollar sales data has been erased from the spread sheets shown in this appendix.

Cost Modeling (Concorde Systems)

	Cost Calculation(Current)			Cost Calculation (Post Trimming)			
				Best case scenario		Worst case scenario	
	July1 - Sept 30 1996	*% of COGS*	*% of TVC*	*% saving*		*% saving*	
Revenues	-				-		-
Cost of Goods Sold (COGS)	-				-		-
Materials	-	90%	85%	0%	-	0%	-
Labor	-	10%	9%	50%	-	20%	-
	-	100%	94%		-		-
Carrying Costs	-	4.50%	4.24%	23%	-	11%	-
Reconfiguration	-	1.00%	0.94%	50%	-	10%	-
Short Ship, Wrong Ship	-	0.50%	0.47%	50%	-	10%	-
Product Maint.	-	0.01%	0.01%	80%	-	50%	-
Total Variable Cost (TVC)	-		100%		-		-
Profit After Variable Cost(PAVC)	-				-		-
PVAC margin	63.00%				65.37%		63.93%
Savings as % of PAVC					3.76%		1.47%

Cost Modeling (Venue Systems)

	Cost Calculation(Current)			Cost Calculation (Post Trimming)			
				Best case scenario		Worst case scenario	
	July1 - Sept 30 1996	*% of COGS*	*% of TVC*	*% saving*		*% saving*	
Revenues	-				-		-
Cost of Goods Sold (COGS)	-				-		-
Materials	-	93%	88%	0%	-	0%	-
Labor	-	7.0%	7%	50%	-	20%	-
	-	100%	94%		-		-
Carrying Costs	-	4.50%	4.24%	23%	-	11%	-
Reconfiguration	-	1.00%	0.94%	50%	-	10%	-
Short Ship, Wrong Ship	-	0.50%	0.47%	50%	-	10%	-
Product Maint.	-	0.01%	0.01%	80%	-	50%	-
Total Variable Cost (TVC)	-		100%		-		-
Profit After Variable Cost(PAVC)	-				-		-
PVAC margin	53.43%				55.75%		54.33%
Savings as % of PAVC					4.35%		1.69%

Appendix 2

This appendix outlines the various steps PictureTel should take to monitor sales of various configurations. The process involves extracting data from the database software Cross Target and analyzing it with Perl scripts.

The following are the steps to analyze sales data for Complete systems in a given quarter

1. Open Cross target model for the quarter and synthesize a view displaying serial number, model name, model description, order number, system quantity, total quantity fields, in that order.
2. Sort the display first by order number and then by model description
3. Copy and paste the entire display into a text file and call it `<quarter>.txt` (Sales data file for the first quarter of 1996 would be called q196.txt).
4. Run the script `ship.pl` with `<quarter>.txt` as the input file. The output file is called `<quarter>out.txt`.
5. Open this output file as a `<quarter>out.xls` Excel spread sheet and view the sales of various configurations in that quarter. Excel can be used sort configurations by sales volume. New fields, like total sales and sales of configurations as a percentage of total sales, can be added.

A sample `quarterout.xls` is shown in the Quarterly Sales Report section of this appendix.

To generate a consolidated report of various quarters

1. Eliminate all fields except the system name, language kit name, country kit name and total systems sold fields from the `<quarter>out.xls` spread sheet and save it was a text file `<quarter>t.txt`.
2. Run `sorter.pl` script with all the `<quarter>t.txt` files by hard-coding their names into the script. The output file generated, called `sales.txt`, is opened as a excel spread sheet `sales.xls`.

Several samples of `sales.xls` are shown in the Consolidated Sales Report section of this appendix. Note that the samples show only 80% of the sales (the complete report is very long.)

Model name, Language kit name, Country kit name and confidential sales data have been erased from the spread sheets shown in this appendix.

A sample of perl scripts `ship.pl` and `sorter.pl` used for the complete Venue systems is shown in the Scripts section of this appendix. Similar scripts can be used to monitor the Main system and Concorde sales.

Reports

Quarterly Sales Report

This section contains sample sales reports. A explanation of different fields is given below.

The Model column contains the system model number. The LK column and CK column contain the model number of the language kit and country kit respectively. The Actual column shows the number of Complete systems with one language kit and country kit associated with each system sale. Missing LK column shows the number of systems sold which do not have an associated language kit in the sales database. Missing CK denotes the number of systems sold which do not have an associated country kit in the sales database. In the case of a missing language kit and/or a country kit, default kits are assigned to the system (an American english language kit and American country kit are defaults.) Multiple CK, LK shows the number of systems sold that have multiple language and/or country kits associated with each system. The Other column contains sales data of systems that have issues other than the ones covered above. For example, a system sold without an associated country kit but with multiple language kits falls in the Other category. The Total field is the sum of the data in Actual, Missing CK, Missing LK, Missing CK LK, Multiple CK LK, and Other columns. '% of Ship' is Total as a percentage of all the configurations sold in a product line. 'Cum %' for a given model is the sum of '% of Ship' of all the models that precede the model in the report, added to its own '% of Ship'

Q495 represents the sales data for fourth quarter of 95. For any Q*XXX* field, the second letter in the field stands for the quarter number and the last two digits the associated year.

Sample of Quarterout.xls

This section shows sample of a quarterly report of Complete system sales.

Model	LK	CK	Actual	Missing LK	Missing CK	Missing CK,LK	Multiple CK,LK	Other	TOTAL	% of Ship	Cum %
-	-	-	-	-	-	-	-	-	-	10.38%	10.38%
-	-	-	-	-	-	-	-	-	-	9.43%	19.81%
-	-	-	-	-	-	-	-	-	-	8.65%	28.46%
-	-	-	-	-	-	-	-	-	-	8.18%	36.64%
-	-	-	-	-	-	-	-	-	-	7.23%	43.87%
-	-	-	-	-	-	-	-	-	-	5.82%	49.69%
-	-	-	-	-	-	-	-	-	-	5.66%	55.35%
-	-	-	-	-	-	-	-	-	-	5.35%	60.69%
-	-	-	-	-	-	-	-	-	-	4.87%	65.57%
-	-	-	-	-	-	-	-	-	-	4.09%	69.65%
-	-	-	-	-	-	-	-	-	-	2.83%	72.48%
-	-	-	-	-	-	-	-	-	-	2.52%	75.00%
-	-	-	-	-	-	-	-	-	-	2.20%	77.20%
-	-	-	-	-	-	-	-	-	-	2.04%	79.25%
-	-	-	-	-	-	-	-	-	-	1.89%	81.13%
-	-	-	-	-	-	-	-	-	-	1.89%	83.02%
-	-	-	-	-	-	-	-	-	-	1.57%	84.59%
-	-	-	-	-	-	-	-	-	-	1.42%	86.01%
-	-	-	-	-	-	-	-	-	-	1.10%	87.11%
-	-	-	-	-	-	-	-	-	-	1.10%	88.21%
-	-	-	-	-	-	-	-	-	-	0.94%	89.15%
-	-	-	-	-	-	-	-	-	-	0.94%	90.09%
-	-	-	-	-	-	-	-	-	-	0.79%	90.88%
-	-	-	-	-	-	-	-	-	-	0.79%	91.67%
-	-	-	-	-	-	-	-	-	-	0.79%	92.45%
-	-	-	-	-	-	-	-	-	-	0.63%	93.08%
-	-	-	-	-	-	-	-	-	-	0.63%	93.71%
-	-	-	-	-	-	-	-	-	-	0.63%	94.34%
-	-	-	-	-	-	-	-	-	-	0.63%	94.97%
-	-	-	-	-	-	-	-	-	-	0.63%	95.60%
-	-	-	-	-	-	-	-	-	-	0.63%	96.23%
-	-	-	-	-	-	-	-	-	-	0.47%	96.70%
-	-	-	-	-	-	-	-	-	-	0.31%	97.01%
-	-	-	-	-	-	-	-	-	-	0.31%	97.33%
-	-	-	-	-	-	-	-	-	-	0.31%	97.64%
-	-	-	-	-	-	-	-	-	-	0.31%	97.96%
-	-	-	-	-	-	-	-	-	-	0.31%	98.27%
-	-	-	-	-	-	-	-	-	-	0.31%	98.58%
-	-	-	-	-	-	-	-	-	-	0.16%	98.74%
-	-	-	-	-	-	-	-	-	-	0.16%	98.90%
-	-	-	-	-	-	-	-	-	-	0.16%	99.06%
-	-	-	-	-	-	-	-	-	-	0.16%	99.21%
-	-	-	-	-	-	-	-	-	-	0.16%	99.37%
-	-	-	-	-	-	-	-	-	-	0.16%	99.53%
-	-	-	-	-	-	-	-	-	-	0.16%	99.69%
-	-	-	-	-	-	-	-	-	-	0.16%	99.84%
-	-	-	-	-	-	-	-	-	-	0.16%	100.00%
-	-	-	-	-	-	-	-	-	-	0.16%	100.16%
-	-	-	-	-	-	-	-	-	-	-0.16%	100.00%
		Total	-	-	-	-	-	-	-		

Consolidated Sales Report (Sales.xls)

Concorde Systems

Concorde (Complete Systems)

No.	System	LK	CK	Q495	Q196	Q296	Q396	Total	% of Ship	Cum %
1	-	-	-	-	-	-	-	-	9.02%	9.02%
2	-	-	-	-	-	-	-	-	8.63%	17.64%
3	-	-	-	-	-	-	-	-	5.48%	23.12%
4	-	-	-	-	-	-	-	-	4.81%	27.93%
5	-	-	-	-	-	-	-	-	3.17%	31.10%
6	-	-	-	-	-	-	-	-	2.63%	33.74%
7	-	-	-	-	-	-	-	-	2.61%	36.35%
8	-	-	-	-	-	-	-	-	2.59%	38.93%
9	-	-	-	-	-	-	-	-	2.57%	41.50%
10	-	-	-	-	-	-	-	-	2.35%	43.85%
11	-	-	-	-	-	-	-	-	2.03%	45.88%
12	-	-	-	-	-	-	-	-	1.92%	47.80%
13	-	-	-	-	-	-	-	-	1.64%	49.44%
14	-	-	-	-	-	-	-	-	1.64%	51.08%
15	-	-	-	-	-	-	-	-	1.53%	52.61%
16	-	-	-	-	-	-	-	-	1.47%	54.08%
17	-	-	-	-	-	-	-	-	1.45%	55.52%
18	-	-	-	-	-	-	-	-	1.42%	56.95%
19	-	-	-	-	-	-	-	-	1.40%	58.35%
20	-	-	-	-	-	-	-	-	1.25%	59.60%
21	-	-	-	-	-	-	-	-	1.23%	60.83%
22	-	-	-	-	-	-	-	-	1.21%	62.04%
23	-	-	-	-	-	-	-	-	1.10%	63.14%
24	-	-	-	-	-	-	-	-	1.08%	64.21%
25	-	-	-	-	-	-	-	-	1.06%	65.27%
26	-	-	-	-	-	-	-	-	0.93%	66.20%
27	-	-	-	-	-	-	-	-	0.91%	67.11%
28	-	-	-	-	-	-	-	-	0.88%	67.99%
29	-	-	-	-	-	-	-	-	0.82%	68.81%
30	-	-	-	-	-	-	-	-	0.82%	69.63%
31	-	-	-	-	-	-	-	-	0.80%	70.43%
32	-	-	-	-	-	-	-	-	0.78%	71.20%
33	-	-	-	-	-	-	-	-	0.75%	71.96%
34	-	-	-	-	-	-	-	-	0.73%	72.69%
35	-	-	-	-	-	-	-	-	0.67%	73.36%
36	-	-	-	-	-	-	-	-	0.63%	73.99%
37	-	-	-	-	-	-	-	-	0.63%	74.61%
38	-	-	-	-	-	-	-	-	0.63%	75.24%
39	-	-	-	-	-	-	-	-	0.60%	75.84%
40	-	-	-	-	-	-	-	-	0.56%	76.40%
41	-	-	-	-	-	-	-	-	0.56%	76.96%
42	-	-	-	-	-	-	-	-	0.54%	77.50%
43	-	-	-	-	-	-	-	-	0.54%	78.04%
44	-	-	-	-	-	-	-	-	0.52%	78.56%
45	-	-	-	-	-	-	-	-	0.50%	79.06%
46	-	-	-	-	-	-	-	-	0.47%	79.53%
47	-	-	-	-	-	-	-	-	0.43%	79.96%
48	-	-	-	-	-	-	-	-	0.43%	80.39%
			Total	-	-	-	-	-		

Concorde (Main Systems)

No.	System	Q495	Q196	Q296	Q396	Total	% of Ship	Cum %
1	-	-	-	-	-	-	14.30%	14.30%
2	-	-	-	-	-	-	11.66%	25.96%
3	-	-	-	-	-	-	6.95%	32.92%
4	-	-	-	-	-	-	5.66%	38.57%
5	-	-	-	-	-	-	4.69%	43.26%
6	-	-	-	-	-	-	4.30%	47.56%
7	-	-	-	-	-	-	4.08%	51.64%
8	-	-	-	-	-	-	4.04%	55.68%
9	-	-	-	-	-	-	3.52%	59.20%
10	-	-	-	-	-	-	3.13%	62.33%
11	-	-	-	-	-	-	3.09%	65.42%
12	-	-	-	-	-	-	2.98%	68.40%
13	-	-	-	-	-	-	1.73%	70.13%
14	-	-	-	-	-	-	1.64%	71.77%
15	-	-	-	-	-	-	1.47%	73.24%
16	-	-	-	-	-	-	1.45%	74.69%
17	-	-	-	-	-	-	1.36%	76.05%
18	-	-	-	-	-	-	1.27%	77.32%
19	-	-	-	-	-	-	1.27%	78.60%
20	-	-	-	-	-	-	1.19%	79.78%
21	-	-	-	-	-	-	1.14%	80.93%
	Total	-	-	-	-	-		

Venue Systems

Venue (Complete Systems)

No.	System	LK	CK	Q495	Q196	Q296	Q396	Total	% of Ship	Cum %
1	-	-	-	-	-	-	-	-	7.60%	7.60%
2	-	-	-	-	-	-	-	-	7.53%	15.14%
3	-	-	-	-	-	-	-	-	6.11%	21.25%
4	-	-	-	-	-	-	-	-	5.79%	27.04%
5	-	-	-	-	-	-	-	-	5.29%	32.34%
6	-	-	-	-	-	-	-	-	4.80%	37.14%
7	-	-	-	-	-	-	-	-	4.69%	41.83%
8	-	-	-	-	-	-	-	-	4.58%	46.41%
9	-	-	-	-	-	-	-	-	3.87%	50.28%
10	-	-	-	-	-	-	-	-	3.80%	54.09%
11	-	-	-	-	-	-	-	-	3.41%	57.50%
12	-	-	-	-	-	-	-	-	2.84%	60.34%
13	-	-	-	-	-	-	-	-	2.84%	63.18%
14	-	-	-	-	-	-	-	-	2.63%	65.81%
15	-	-	-	-	-	-	-	-	2.56%	68.37%
16	-	-	-	-	-	-	-	-	1.81%	70.18%
17	-	-	-	-	-	-	-	-	1.74%	71.93%
18	-	-	-	-	-	-	-	-	1.60%	73.53%
19	-	-	-	-	-	-	-	-	1.60%	75.12%
20	-	-	-	-	-	-	-	-	1.21%	76.33%
21	-	-	-	-	-	-	-	-	1.21%	77.54%
22	-	-	-	-	-	-	-	-	1.14%	78.68%
23	-	-	-	-	-	-	-	-	1.14%	79.82%
24									0.92%	80.74%
			Total	-	-	-	-	-		

Venue (Main Systems)

No.	System	Q495	Q196	Q296	Q396	Total	% of Ship	Cum %
1	-	-	-	-	-	-	19.08%	19.08%
2	-	-	-	-	-	-	15.14%	34.22%
3	-	-	-	-	-	-	9.49%	43.71%
4	-	-	-	-	-	-	8.42%	52.13%
5	-	-	-	-	-	-	5.58%	57.71%
6	-	-	-	-	-	-	6.82%	64.53%
7	-	-	-	-	-	-	7.25%	71.78%
9	-	-	-	-	-	-	9.13%	80.92%
	Total	-	-	-	-	-		

Scripts

Ship.pl

```
#!/usr/bin/perl
############################################################
#This program takes a output text file from Cross target, #
#Quarter.txt, with field separated by tabs, and sorts     #
# the sales data by configurations.                       #
############################################################
$prod = 2;
$num = 1;
$• = 3;
$quant = 4;
$cord = 0;
$wrcoun = 0;
#****************FOR VALUE GROUP SYSTEMS ONLY***************
$dcount = 'S2-CK-A';
$dlang = 'S2-LK-E';
$sysnum = "S2";
#************************************************************
# READ THE NAME OF THE FILE CONTAINING THE DATA
print "give the name of the data file:";
chop($file= <STDIN>);
@name = split(/\./,$file);
$name = $name[0];
$out1 = "out.txt";
$out = $name.$out1;
open(DINP, "<$file") || die; #INPUT DATA FILE IS <QUARTER>.TXT
open(DOUT, ">$out") || die; #OUTPUT DATA FILE IS <QUARTER>OUT.TXT

#READ EACH LINE FROM QUARTER.TXT AND SORT SALES OF
#DIFFERENT CONFIGURATIONS
while (<DINP>) {
```

```
@comp = split(/\t/,$_);
# FIND OUT WHETHER THE LINE REPRESENTS A SYSTEM OR LANGUAGE KIT
# OR COUNTRY KIT
if ("$comp[$ord]" ne "$cord") {
      $cflag = 0;
      $lflag = 0;
      $ccount = $dcount;
      $clang  = $dlang;
      $cord = $comp[$ord];
}
# IF THE CURRENT LINE CONTAINS A COUNTRY KIT, INCREMENT CFLAG
if ($comp[$num] =~ /(.*)CK(.*)/) {
      $ccount = $comp[$num];
      ++$cflag ; # NUMBER OF COUNTRY KIT ASSOCIATED WITH A SYSTEM
}
# IF THE CURRENT LINE CONTAINS A LANGUAGE KIT, INCREMENT LFLAG

if ($comp[$num] =~ /(.*)LK(.*)/) {
      $clang = $comp[$num];
      ++$lflag ; # NUMBER OF LANGUAGE KIT ASSOCIATED WITH A SYSTEM
}

# IF THE CURRENT LINE CONTAINS A SYSTEM, FIND THE ASSOCIATED LANGUAGE
# KIT AND COUNTRY KIT AND INCREMENT THE 'NUMBER OF SYSTEMS SOLD' FIELD
# FOR THAT CONFIGURATION

if ($comp[$num] =~ /(.*)2\d\d\d(.*)/) {
      if ($cflag > 1) { print ">1 ck order: $comp[$ord]\n";}
      if ($lflag > 1) { print ">1 lk order: $comp[$ord]\n";}
      $system = join('*',$comp[$num],$clang,$ccount);
      $coun += $comp[$quant];
      $model{$system} += 0;
```

```
#CHECK IF THE SYSTEM(S) IS(ARE) ASSOCIATED WITH UNIQUE
#LANGUAGE KIT AND COUNTRY KITS.
      if (($cflag == 1) && ($lflag == 1)) {
            $model{$system} += $comp[$quant];
      }
      elsif (($cflag == 1) && ($lflag == 0)) {
            $lmodel{$system} += $comp[$quant];
      }
      elsif (($cflag == 0) && ($lflag ==1 )) {
            $cmodel{$system} += $comp[$quant];
      }
      elsif (($cflag == 0) && ($lflag == 0)) {
            $lcmodel{$system} += $comp[$quant];
      }
      elsif ((($cflag + $lflag) > 2) && $cflag && $lflag)  {
            $mmodel{$system} += $comp[$quant];
      }
      else  {
            $omodel{$system} += $comp[$quant];
      }
}
} #End of while


# WRITE THE SORTED SALES DATA TO A TEXT FILE
print DOUT ("Model","\t","LK","\t","CK","\t","Actual","\t","Missing
LK","\t","Missing CK","\t","Missing CK,LK","\t","Multiple
CK,LK","\t","Other","\t","TOTAL\n");
foreach (keys %model) {
      $key = $_;
      @compn = split(/\*/,$key);
      $count = $model{$key} + $lmodel{$key} + $cmodel{$key} +
      $lcmodel{$key} + $mmodel{$key} + $omodel{$key};
```

```
        $str = join("\t",@compn);

        printf DOUT ("%s\t%d\t%d\t%d\t%d\t%d\t%d\t%d\n",
        $str,$model{$key},$lmodel{$key},$cmodel{$key},$lcmodel{$key},$mmod
        el{$key},$omodel{$key},$count);
} # END OF PROGRAM
```

Sorter.pl

```
#!/usr/bin/perl
#####################################################
# This file takes the <quarter>t.txt files merges  #
# them into a single report file. The files names  #
# are hard coded into this file.                   #
#####################################################
$sys = 0; # THE CONFIGURATION NAME IS IN THE FIRST COLUMN OF QUARTER.TXT
$lk = 1; # THE LANGUAGE KIT NAME IS IN THE SECOND COLUMN OF QUARTER.TXT
$ck = 2; # THE COUNTRY KIT NAME IS IN THE THIRD COLUMN OF QUARTER.TXT
$num = 3; # THE NUMBER OF SYSTEMS SOLD IS IN THE FOURTH COLUMN OF
          # QUARTER.TXT

open(DINP1, "<q495t.txt") || die; # NAME OF THE INPUT FILE HARDCODED
open(DINP2, "<q196t.txt") || die; # NAME OF THE INPUT FILE HARDCODED
open(DINP3, "<q296t.txt") || die; # NAME OF THE INPUT FILE HARDCODED
open(DOUT, ">sales.txt") || die;  # OUTPUT FILE SALES.TXT

##### MERGE THE DATA FROM DIFFERENT QUARTERS #####

# READ DATA FOR Q4 95
while (<DINP1>) {
      @comp = split(/\t/,$_);
      $system = join('*',$comp[$sys],$comp[$lk],$comp[$ck]);
      ++$prod{$system};
      $q495{$system} = $comp[$num];
}
```

```
# READ DATA FOR Q1 96
while (<DINP2>) {
      @comp = split(/\t/,$_);
      $system = join('*',$comp[$sys],$comp[$lk],$comp[$ck]);
      ++$prod{$system};
      $q196{$system} = $comp[$num];
}

# READ DATA FOR Q2 96
while (<DINP3>) {
      @comp = split(/\t/,$_);
      $system = join('*',$comp[$sys],$comp[$lk],$comp[$ck]);
      ++$prod{$system};
      $q296{$system} = $comp[$num];
}

# WRITE THE SORTED SALES DATA TO THE OUTPUT FILE
print DOUT ("System\t", "LK\t", "CK\t", "Q495\t", "Q196\t", "Q296\t",
"Total\n");
foreach (keys %prod) {
      $key = $_;
      @compn = split(/\*/,$key);
      $total = $q495{$key} + $q196{$key} + $q296{$key};
      $str = join("\t",@compn);
      printf DOUT ("%s\t%d\t%d\t%d\t%d\n",$str,$q495{$key}, $q196{$key},
      $q296{$key}, $total);
} # END OF PROGRAM
```

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