Title: Comparison of Concurrent Engineering Management with Traditional Project Management

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Abstract: This project is to describe concurrent engineering and show how it can be used to improve product development projects. Some basic aspects of concurrent engineering is studied, including comparison with traditional methods, quality function deployment, and concurrent development teams. First, concurrent engineering is introduced and compared with traditional management philosophy. Some of the benefits of concurrent engineering are described; then, a major tool used in concurrent engineering: quality function deployment ; the roles and communication within the project team, and comparison of this with and industry example; some examples of successful use of CE in product development organizations.

COMPARISON OF CONCURRENT ENGINEERING MANAGEMENT WITH TRADITIONAL PROJECT MANAGEMENT

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EMGT 545

JUNE 1994

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Abstract

The purpose of this report is to describe concurrent engineering and show how it can be used to improve product development projects. We will study some basic aspects of concurrent engineering, including comparison with traditional methods, Quality Function Deployment, and concurrent development teams.

There are many advantages to using concurrent engineering in product development, more than can be discussed in this report. The intent of this report is to give the reader an understanding of the basics of concurrent engineering and how it is applied.

First, concurrent engineering is introduced and compared with traditional management philosophy. Some of the benefits of concurrent engineering are described, such as development time, cost savings and improved quality. We will then describe a major tool used in concurrent engineering: Quality Function Deployment (QFD). This section will show how QFD is used to assure that the product meets the customers needs. Then we will discuss the roles and communication within the project team, and compare with this with an industry example. Finally some examples of successful use of CE in product development organizations are presented.

Introduction:

Concurrent Engineering is a management methodology for new product development that began in the 1980's with an effort by the Defense Advanced Research Agency (DARPA) to look for ways to improve the concurrency in the design process. This effort led to expanded efforts by the Institute for Defense Analyses (IDA) to study the area and define the process and subject. IDA has issued reports on the subject (R-338) and presented a formal definition that is most often used when defining concurrent engineering (CE).

> "Concurrent engineering is a systematic approach to the integrated, concurrent design of products and their related processes, including manufacture and support. This approach is intended to cause the developers, from the outset, to consider all elements of the product life cycle from concept through disposal, including quality, cost, schedule, and user requirements."
>
> IDA Report R-338

An industry steering group referred to as CALS (Computer-aided Acquisition and Logistic Support) began a study of the subject and published their first report in 6/85. Subsequently they have published reports 002 (1988), 003, 004 and 005 (1991). The group contains members from different large corporations (Northrop, General Dynamics, Martin Marietta, Rockwell, GTE, Boeing, TRW, Raytheon, Honeywell, AT&T) as well as IDA and the Department of Defense. University input is also present in this steering group (Northeastern University, University of Southern California, etc.).

In addition, CE has become the area research within the university community and has led to other definitions on the subject which are enlightening:

Concurrent Engineering is delivering better, cheaper and faster products to the market, by a lean way of working, using multi-disciplinary teams, right first time methods and parallel processing activities to *continuously consider all constraints.*

Dr. Stephen Evans
Cranfield CIM Institute

In practice, the application of Concurrent Engineering methods means:

* "team building" - breaking down the cultural and organizational barriers between disciplines in the design, manufacture, and support processes;

* integration of the systems used by the disciplines involved in these teams.

Julian Fowler, CADDETC
University of Leeds, UK

Concurrent Engineering is a systematic communication between team members to enable consideration of all important product and process information in a timely manner. This implies structured information management. This in turn implies understanding of the design process and the development of product information.

David G. Ullman
Oregon State University

Purpose and Scope

The purpose of this project is to look at concurrent engineering from a slightly different viewpoint. Concurrent engineering is also a project management methodology which differs substantially from traditional project management. Project management is a much broader area than concurrent engineering management. Concurrent engineering management deals with only new product development primarily with an organization.

While it is not impossible for organizations to contract out development work and at the same time use concurrent engineering philosophy, it becomes much more difficult. This is because the developers must work together in a team situation where the team has a common vision and focus on what the goals of the project are. Much of the traditional conflict arising with matrix organizations or pure project development organizations using contractors is bypassed using this philosophy. Walls between functional areas are torn down.

Is it limited to product development?

Concurrent engineering management is a project management system for new product development. It focuses on shortening the development time for new products while at the same time improving new product quality and customer satisfaction. This management system develops the product using teamwork and a common vision focusing on customer needs and the full lifecycle of the product.

Team OIT

June 1994

Concurrent engineering management is a subset of traditional project management. However, it focuses and emphasizes different fundamentals than traditional project management. Classically traditional project management focuses on time, cost and performance. Concurrent engineering management focuses on time, quality, and customer satisfaction. While these difference may not seem large, concurrent engineering in fact, requires, "fundamental, wrenching, far-reaching transformations throughout the enterprise."[1]

The goal of this paper is to:

* *contrast the differences between traditional project management and concurrent engineering management.*

* *document the benefits, methodology, and challenges of implementing concurrent engineering..*

I. Overview

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[1] Hayes, H. and Wheelwright, S.; *Dynamic Manufacturing; (New York: Free Press, A Division Macmillian, Inc., 1988)*

I.1 Product Lifecycles and Development Time

Any product placed on the market has a finite life cycle. That lifecycle may be measured in hundreds of years but in this day and age it is being increasingly measured in months. Products that become commodities tend to have longer lifecycles. Products such as computer memory chips or microprocessors however have very short lifecycles. They are continually being improved and remarketed as the previous model starts to decline.

With products that have a short lifetime, the time between decline and new product introduction is critical to the viability of the companies producing the product. In a competitive marketplace, the company which introduces a new evolution of a product before his competitors can counter will reap large rewards. This stems from the fact that the highest profits from a product usually come within a short period after introduction when one single companies dominates the marketplace before competition comes in and forces a drop in the pricing structure.

If a company fails to introduce the next generation of his product before the current generation begins to decline, those profits can never be recovered since the new product will also have finite lifetime. If a company fails to introduce a new product before his competitors do, unrecoverable profits will also be lost.

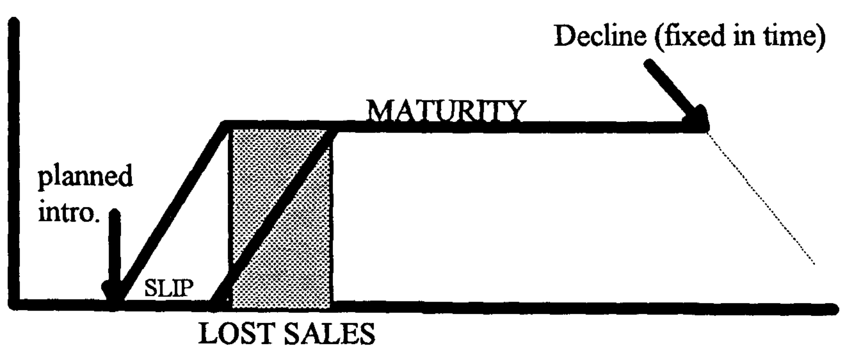

FIGURE 2

Where is Figure 1?

This introduces a first point in contrast between traditional project management and concurrent engineering management. In many traditional project management scenarios, time, cost and performance are all looked at as of equal importance in managing a project. In fact, often in managing traditional projects, if a choice arises between time and cost, the choice will many times be that of delaying the project instead of adding resources to keep it on time. With concurrent engineering, "getting a quality product to market <u>fast for a fair value is the name of the game.</u>"[2]

* With concurrent engineering of new products, ***<u>development time</u> is*** absolutely critical.

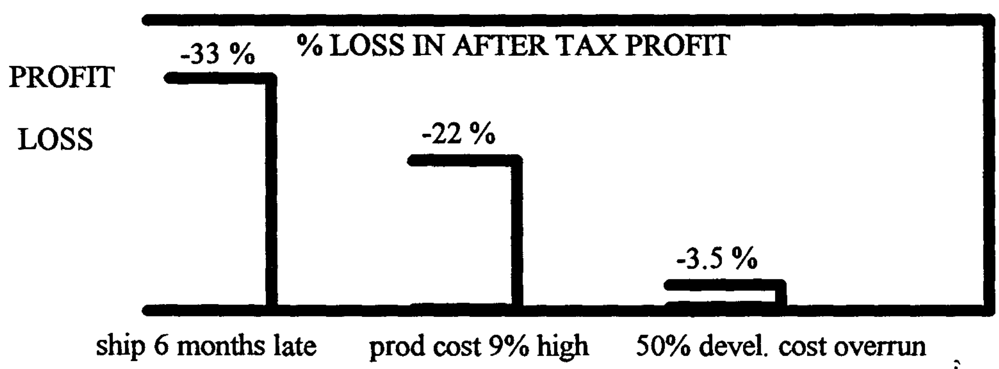

FIGURE 3

Source: Mckinsey & Co (give full reference)

I.2 Traditional Project Management Organization

The management system in a traditional product development organization is often a matrix structure. This system has one or more product development projects. The project manager will negotiate with the functional managers for resources to accomplish his goals. This often

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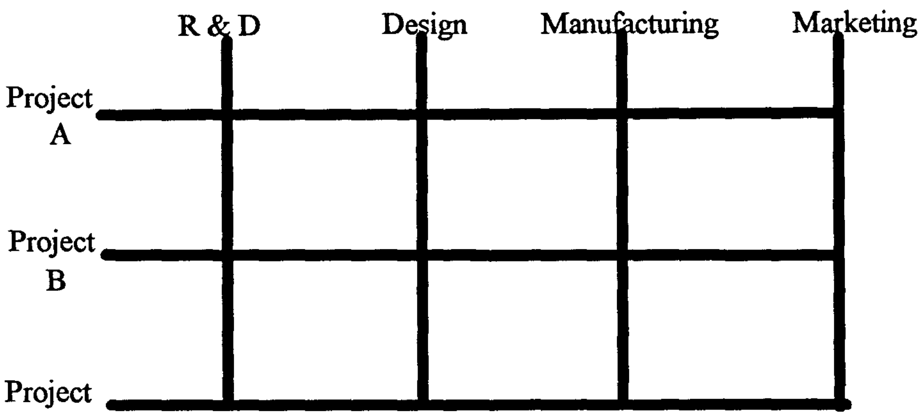
[2]Carter, D. and Baker, B.; *CE Concurrent Engineering -- The Product Development Environment for the 1990s; p. 26; (Massachusetts: Addison-Wesley Publishing Company; 1992)*

breeds conflict as the functional managers have no say or "buy-in" to the project. Often times, their feelings about the merit of the project will be reflected in the resources they give to the project.



Matrix Organization
Figure 4

Project managers have the responsibility to manage the project but really don't have the power to obtain resources and resolve problems as needed. Departmental managers have the responsibility to allocate resources but often no input into the conceptual phase of the project. Departmental managers will often either not understand why a project is being done, not agree with it, or not like the manner it is being done. Essentially both the project manager and the departmental managers are being told to get this project done in the manner prescribed. They had no input into the project in the initial stages and now must spend time and resources patching mistakes and making design changes to make the product functional.

For instance, it is not unusual for a vice-president or some other powerful manager to have a "pet idea" about a new product or product features. He will then ask R&D to come up with a concept design for his idea. R&D comes up with a conceptual design and makes a prototype in a highly specialized shop. They then send it to marketing to determine if indeed there is a market for the product. Marketing says no but if R&D changes this and that, maybe it will sell. R&D adds on to the project

Project mgr. is a "strong" matrix" could be very powerful increasing the design complexity. They minimally test the new prototype since the project manager is now involved and pushing to keep the project on schedule. Instead they send their results to finance who determines what the production costs and selling price must be at projected sales level to provide an adequate rate of return. The design department comes up with a detailed design and sends it to manufacturing. Manufacturing then says they doesn't have the capability to make the item and send it backs to design for design patching and back to finance for new estimates at realistic production rates. Design patches the problems and sends the new drawings back to manufacturing. Manufacturing still really can't meet the product specs. However they "know design probably doesn't really need those specs that tight". Since the project manager is pushing to keep the project on time, they cut some corners and do the best they can and release it.

Every time a problem comes up, meetings with busy departmental managers must be arranged by the project manager to try to resolve the problem. The "ball" bounces back and forth over the walls between departments in efforts to resolve problems and get the product out onto the market within the time and cost frames outlined in the project (with the performance features left somewhat intact). Resources are renegotiated between the project manager and the functional managers as the project manager tries to resolve all the problems and design changes that come up. Frustration builds as problems mount. One department solves a problem only to find the solution created another problem for some other department. Tensions between the project manager and the functional managers increase. Tensions between the functional managers also build as each looks out for only his area and not for what is good for the project and company as a whole.

This management system creates project delays and quality problems. "85% of problems with new products- not working as they should, taking too long to bring to market, costing too much - is the result of a poor design process."[3] The highly structured matrix organization with its long communications lines does not attack problems adequately in the concept

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[3]Ullman, D.; *The Mechanical Design Process; p. 3, (New Jersey: McGraw-Hill, 1992)*

phase and when it does attack problems, it is in a very inefficient manner. Exactly who is responsible for resolving the problem is often times not clear. Problems therefore may not get resolved properly. The large number of design changes hurts the functionality and quality of the final product. Taguchi has defined a loss function as "the financial loss to society imparted by the product due to deviation of the product's functional characteristic from it's desired target value".[4] Each time a product is redesigned to patch a problem, the quality and functionality of the product drops.

Once the product is on the market, it doesn't sell well because it costs more than originally planned, the quality is poor from all of the design changes, and it is very hard to service since the service department was not involved at all in the project. In addition, the competition using concurrent engineering, came out with a new model several months ago that does everything the customers wanted (not what some important manager wanted).

I.3 Concurrent Engineering Management Structure

Concurrent engineering project management structure is substantially different from matrix project management. "Paying attention to concurrent engineering efforts, which might involve some training and organizing of multidisciplinary teams, might initially be considered as contrary to the goal of shortened time to market. Many design engineering managers have resisted concurrent engineering because of this aspect."[5] Instead of a single project manager running a product development project, a team of individuals drawn from the functional organizations is permanently assigned to the product development project from conception to finish. This team has no other organizational responsibilities and works solely on this project. Sometimes a team leader is selected from within the people of this team and sometimes the team leader is rotated as the project passes through different stages.

* Concurrent engineering replaces the function of project manager with a team leader drawn from the development

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[4]Taguchi, G.; *System of Experimental Design; (New York: UNIPUB-Kraus International Publications, 1976)*

[5]Shina, S.; *Concurrent Engineering and Design for Manufacture of Electronic Products;* p. 103, (New York: Van Nostrand Reinhold, 1991)

* Concurrent engineering replaces the function of project manager with a team leader drawn from the development team.

* Concurrent engineering uses a team empowered by top management to make decisions by a consensus making process.

The team is directly involved in concept development. This is very important since it gives the functional representatives a chance to address their concerns up-front rather than patching solutions in later. This in effect allows the functional departments to "buy-in" and design out many of the problems that they would otherwise have to solve later on.

The project is aligned with the mission, vision, values, and goals of the organization. Top management has put its stamp of approval on the project and empowered the team to carry out the project. "Management must empower team members and trust their collective decisions".[6] The team has the authority and the ability to fairly accurately determine the needs of the project at its inception since there will be less redesign and renegotiation later on. The team has a direct line into the functional departments by someone normally assigned there and familiar with the people and technology. This also lowers the conflict levels since someone familiar to the department manager and trusted by the department manager is the interface with the project. This does not completely eliminate conflict but it substantially reduces it.

*** Concurrent engineering uses "buy-in" and teamwork to address** concerns up-front in the concept stage and thus avoiding many of the conflicts normally present.

[6]Logendran, L.; "Manufacturing Operations" ; Class Handout, Depart of I.E, O.S.U., Fall 1993

Table of Comparison of Management Styles

Management Directed	*Team Directed*
Project Manager As Scheduler but with limited authority to match responsibility	Team Leader as Product Champion
Participants operate on many projects at same time	Members assigned on one project at one time
Participants shielded from other functions	Members exposed to total company
Long communication loops	Direct communication loops
Tasks negotiated by project manager and functional managers interdependence	Team has common vision and mutual
Project manager assumes responsibility and delegates authority	Members agree on commitment
Functional management must approve decisions.	Management make decisions.

II Comparison of Management Systems

II.1 Development Time / Customer Focus

The project in traditional project development management often focuses on implementation of an idea of top management or R&D. The concept phase has often been completed by the time the project manager gets involved. His job is to push the project design through the development stage and focus on the getting the production stage up and going within time, cost, and performance constraints.

In contrast, concurrent engineering management focuses much of the total project effort on the concept design, partially because of advantages discussed above but mostly because of the time needed to focus on finding out what the customers needs and desires are and converting those desires into engineering requirements. "Force the technical people into exposure with current customers to allow them to see needs."[7] Multiple design concepts are made from the engineering requirements and evaluated for ability to meet the customer requirements. "If you generate one idea, it will probably be a poor idea; if you generate twenty ideas, then you might have one good idea."[8] Multiple functional designs are made from the best concept design and evaluated for cost and performance and ability to fill customer requirements.

The focus on the concept phase prevents problems that would otherwise rise later on in the development of the project. The team focuses on a systemic design that tries to incorporate into the design not only the customer needs, but the concerns of the various functional departments involved. The design phase looks at manufacturability, quality issues, testability issues, repairability issues, environmental issues, product liability issues, and other pertinent issues. This systemic focus reduces drastically the number of changes required later on. The theme of "do it once - do it right!" is the focus of the concept phase. This requires more time, but offers a large payback in terms of reducing the number of redesigns and reducing the total development time.

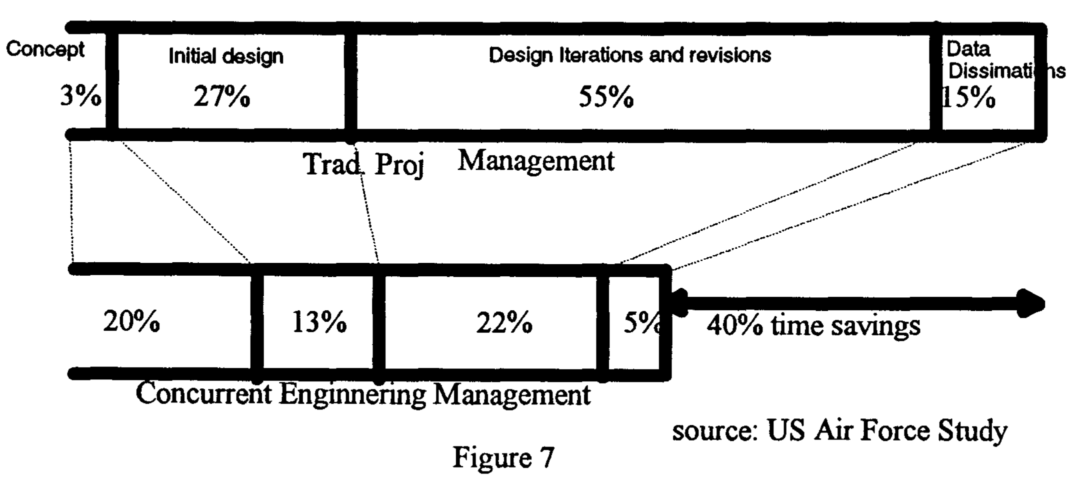


Figure 7

[7]Gobeli, D. and Brown, D. ; "Improving the Process of Product Innovation"; Research - Technology Management, March-April 1993.

[8]Ullman, D.; *The Mechanical Design Process; p. 140, (New Jersey: McGraw-Hill, 1992)*

* Concurrent engineering focus on the design concept phase, engineering out many of the problems that would later occur.

II.2 Cost Savings

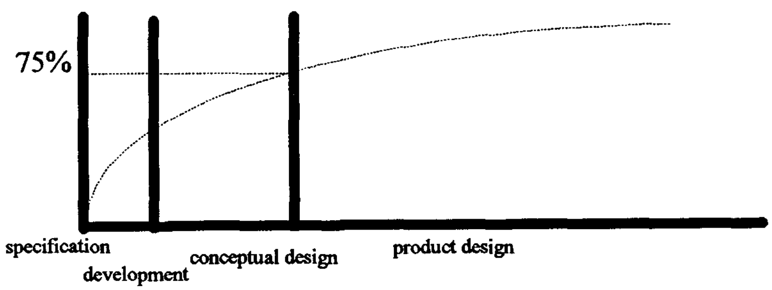
The second reason concurrent engineering focuses on the concept phase is because while little cost is incurred in this phase, *a substantial* amount of the product cost are defined and committed to here. "Thus, the decisions made during the design process have the greatest effect of the cost of a product for the least investment. ... 75% of manufacturing cost is committed by the end of the conceptual phase of the design process".[9]

Changes are much cheaper to repair in the design stage than later on. The comparison is basically a logarithmic one as shown in the following table.[10]

Time of Design Change	*Cost*
Design Phase	$1,000
Testing Phase	$10,000
Process Planning Phase	$100,000
Pilot Production Phase	$1,000,000
Final Production Phase	$10,000,000

•Ullman, D.; *The Mechanical Design Process; p. 9, (New Jersey: McGraw-Hill, 1992)*
[10]Business Week; April 30, 1990

Design Influence on Manufacturing Costs



source: Ullman, Mechanical Design Process

Figure 8

II.3 Quality Improvement

The final reason for focusing on the conceptual design phase is that the product can be designed with the input of manufacturing and service for quality features. Quality must be designed in the product for it to be competitive in the marketplace. Quality is just as much the responsibility of designers as it is the manufacturers. The product must be designed in a manner that manufacturing has the capability of meeting design specifications. The product should also be designed in a manner that produces an easy to assemble, easy to service product with as few parts as possible and with as many standard parts as possible. The more complicated a product is, the more apt that product is to fail.

Per discussion, the next graph above shows the preponderance of design changes completed early in the design cycle in concurrent engineering. While with traditional project management, the lack of work in the conceptual phase results in problems later on in the project cycle. The poorer quality is exhibited by the increase in field returns after shipping date. These returns prevent manufacturing from ramping up to full production limiting potential profits as well as degrading the quality reputation of the product which takes value away from the new product.

A TRW study on the benefits of concurrent engineering concluded "the number of changes over the life of the program was 50% less compared to other projects using the traditional approach."[11] The program costs might be greater in the earlier stage of the project, but the overall program cost are lower because of when the design changes are made and the fewer number of design changes.

SERIAL PRODUCT DEVELOPMENT MODE

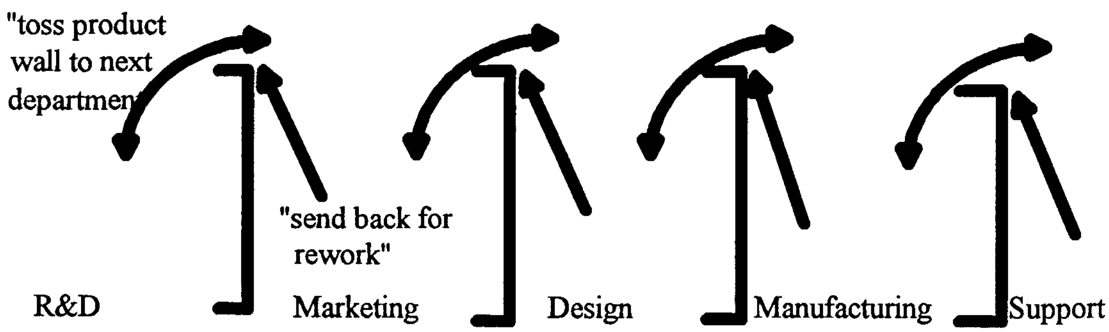


Figure 5

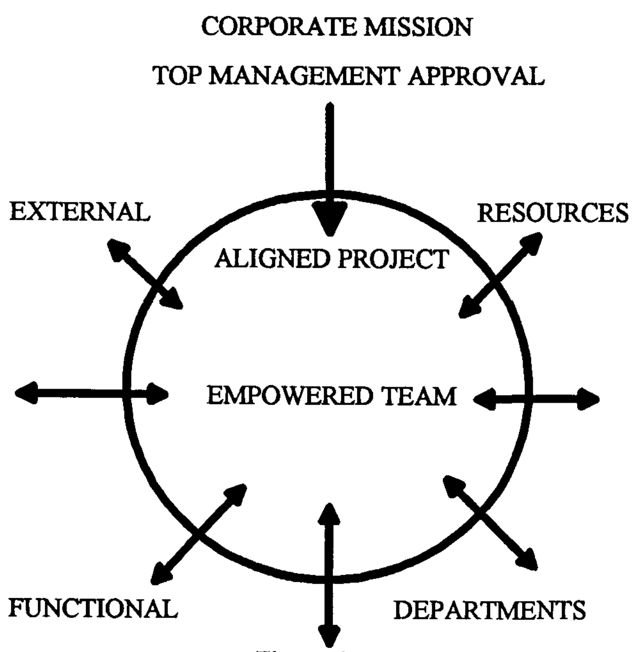


Figure 6

[11]Nickelson, D. and Belson, D.; "Measuring the Economic Impact of Concurrent Engineering"; CALS Journal; Summer 1992

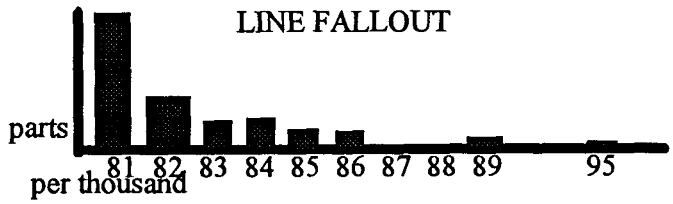
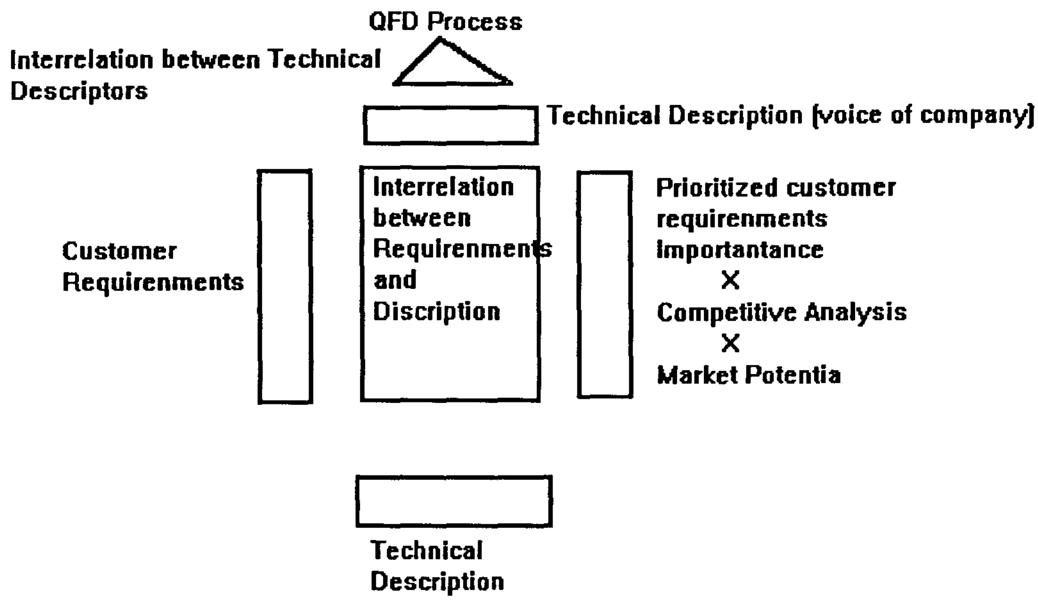


Figure 9 source: Xerox Data

III Quality Function Deployment:

III.1 QFD Definition:

QFD is the process that provides structure to the product development cycle. The structure can be described as a house. The foundation of the house is customer requirements. The framework of the house consist of planning matrix. Planning matrix include items such as the importance rating customer-perceived bench markings, sales point, and scale-up factors. The second floor of the house consist of technical features. The roof of the house is the trade-off of technical features. The walls describes the relationships between the customer requirements and the technical characteristics. Extra parts can be added such as new technologies, functions, process steps, importance rating, and competitive analysis. All components depends upon the scope of the project QFD process is shown in the next page.



Source: Bossert[12]

The primary focus in QFD is the customer requirements. QFD process is driven by what the customer wants, not by innovation in technology. More efforts is needed of getting the information in order to determine what the customer truly wants. This will result in increasing the initial planning time in the project definition phase of development cycle, on the other hand, it reduces the time in putting the product into the market.

After defining the product , QFD is used in the design phase to focus on the key customer requirements, the elements that are very important to the customer. As a result, the design phase is shortened to focus on items that the customer really wants. This efforts will reduce dramatically the time spent on redesign and modifications. This savings is estimated as one-third to one-half of the time taken using traditional means. For many companies, this can mean many dollars saved not only in development cycle but also in additional income brought in due to getting out a product that met the customer's requirements. The danger is using QFD as an end to itself. QFD is only a tool to be utilized where appropriate. It is like any other tool, there are proper and improper ways to use it.

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[12]Bosset J; Quality Function Deployment; What's Quality Function Deployment; p.7; (Wisconsin:ASQC Quality press; 1991)

III.2 QFD Benefits:

QFD benefits can be summarized as shown in the table below.

QFD Benefits

Customer Driven	-Creates focus on customer requirements -Uses competitive information effectively -Prioritize resources -Identifies items that can be acted upon -Structure resident experience/information
Reduce Implementation Time	-Decrease midstream design change -Limits post-introduction problems -Avoid future development redundancies -Identifies future application opportunities -Surface missing assumption
Promotes Teamwork	-Consensus based -Creates communication at interfaces -Identifies action at interfaces -Creates global view out of detail
Provides Documentation	-Documents rationale for design -Is easy to assimilate -Adds structure to the information -Adapts to change, a living document -Provides framework for sensitivity analysis

Source: Bossert, p. 6

III.3 Getting started in QFD:

First, the manager have to be willing to commit his/her people with respect to time. QFD would fail if the team can't meet together.

Therefore, the manager should be willing to give the people involved in the project all the time needed to finish their assignments.

Second, the manager should make sure that everybody in the project understands the importance of the QFD project. All team members should treat QFD as another assignment in the project. This will make the team members spends an appropriate amount of time on QFD.

Third, the objective and goals of the project should be understood by all the team members. By not understanding and defining the scope of the project, there will be many more hours added to the QFD exercise.

Finally, the manager should inform all other managers about the QFD project, its scope, and the team members. This helps to eliminate conflicts when a team member is asked to do more than he/she has time or energy for.

These steps are necessary for success in QFD exercise. The next consideration is what reporting should the manager expect. Studies has shown that if the team leader reports to the manager in a monthly basis, the manager will have enough time to measure progress. The manager must be willing to help the team with its assignments. This will show support for the team.

Another manager task is choosing the team members. There two types of projects. One is making a new product. The other is improving a product. On a new product, the team should consist of the development people, marketing people, business research people, quality assurance people, and manufacturing. The development people will bring the concept into reality and assess the feasibility, marketing will determine the market of the product based on the customer needs, business research will determine the research need to be done to address the unknown categories, quality assurance will insure the quality of the product, and manufacturing will help determine the capability of the current equipment's.

The product development team will include development, marketing, quality assurance, and manufacturing members. The size of this team is smaller because the product already exist. These members will determine the resources needed to make the improvements. The resources are defined as money, people, and equipment.

Prior to the QFD exercise, the team should meet to accomplish two important things. First, to fully understand the scope of the project.

Secondly, to learn about the QFD exercise. Understanding the scope of the project will reduce the time needed for QFD process. In addition to establishing priorities. Understanding QFD process will give the team a feeling for the amount of work and information needed to complete this task.

At the end of the session, the team members will be told when the first meeting will begin and how long it will last. This will establish the importance of the project. The other benefit from this meeting is that it is a good opportunity for the team to meet each other.

Prior to the first official meeting, the sponsor and the facilitator need to establish the format, duration of the meeting, and the frame for the various deliverables. Studies have shown that two-hour sessions is the most efficient time duration. The advantages of the two-hour sessions are ensuring that the right type of information is utilized in building the matrix. The other advantage is that it helps the team members focus in one thing.

The facilitator task is mainly getting the QFD exercise completed in the most efficient manner. His task is enhance that all team members know what to expect, all information is complied quickly, consensus is reached in a timely manner, and corporation is taken place. The facilitator needs to have a close relationship with the team leader. The two have to meet prior to the QFD exercise to review the process, understand the scope of the project, and the people who should in the team.

During the initial meeting, the facilitator needs to make sure that everybody in the team understands the process while the team leader defines the scope of the project. After each meeting, the facilitator should review with the team leader the results of the meeting , the strategy for the next meeting and the recommended methods to gather additional information based on the data received.

III.4 Obtaining Customer information:

Customer information comes from different resources. Some of the resources are solicited and some are not, some are measurable and some are qualitative, some are obtained in a structure manner and some are obtained in a random manner.

Customer requirement data that are solicited, quantitative, and structured tend to take the form of customer surveys, market surveys, trade trials, working with preferred customers, analyzing other manufacture's products, and buying back products from the field. These information will identify where the company stands in the marketplace, it also shows the weakness and strengths of the company. However, these information don't tell where the company is going.

Unsolicited data that are quantitative and structured also have the same weakness, it don't show where the company will be in the future. These data are received from various governmental and regulatory agencies as requirements or standards. It is generally something that has to be followed.

The last type of information is the solicited but more subjective in nature. These information is obtained in a structured manner by means of focus group. Focus group are meeting with various industry leaders that are run by trained facilitators to find out dislikes, likes, trends, and suggestions about current or future product. The meetings are usually recorded in a video tape to be reviewed by sponsoring company. The advantage of these data is that opinions and desires are expressed in terms of customer's words.. The disadvantage is that this information is rarely seen by non marketing people.

There is another information available which can express where the technology is going. It can be solicited by a company looking for qualitative information in a random manner in the form of trade visits to customers and non customers. This is usually done by bringing the customer into the manufacturing and development areas to discuss the things the customer would like to see.

Another resource of information is the unsolicited information that comes from salespeople, service representatives, training programs, conventions and trade shows, and various trade journals, and any other sources such as current suppliers, academic programs, and what employers hear from their friends and neighbors.

QFD can provide an access to these information and place it in a structure to be utilized. These information will show the team not only what the customers say that they want, but what customers want but are not expressing.

III.5 Putting it all together:

Once the customer issue has been decided, then starts the brainstorming sesion to determine what the customer requirenments are. The usual rules of brainstorming are used, all the ideas are valid. The Affinity Diagram is usually used to sort the ideas into categories based on natural relationships. The facilitator should be recording the ideas. A second facilitator can write ideas in a 3X5 cards while the facilitator is writing on a pad. This will save time and provide a learning experience for someone who just learned how to do QFD.

It is important for the facilitator to talk when it is needed. In brainstorming, there are times when silence should take place. This will give the team members time to formulate ideas. Another tasks that the facilitator should do is seeking clarification on terms, and keeping the team focused on what the customer would ask for, not the technical translation.

One thing that is helpful is to write on the back of the 3X5 cards some words that summarize some of the discussion so it will be easier to remember them for future use.

When the brainstorming is completed, the group is briefed on how to do the Affinity sorting. Then each person will place the cards that seem to be related into groups. The team is then sent on a break and the cards is scatter on a large table. After that, the team is asked to find the word that best described each group of cards.

The next step is developing the technical characteristics part of the matrix. If the project is improving current product, the easiest way to start by listing all the technical characteristics that are measured or evaluated in the current product . This way the matrix will show how well the current quality system assures that the product meets customer needs.

After listing everything, the team will sort the cards based on the technical characteristics. As a result, this will create discussion on what should be looked at and usually results in more cards being made to fill the gaps.

The next step is the reality check. A planning matrix is developed which contains the importance rating. The importance rating is the measure where the current product stands from the customer's perspective, where other manufactures stand, where the company should be positioned with the improved product. A scale-up factor is calculated from the scale-up and current position, a sales point, and a weight. The importance rating can use any scale, but it is normally from 1 (low) to 5 (high).

The next columns look at the competition. The competitors should be identified so that everyone on the team knows who they are. It is important that the same scale should be used in these columns. This will show how competitors see the weakness of the product. It is also the start for the company to see how to develop improvements on the product.

The target column is on the same scale as those for the company and the competitors. The decision here is to improve, remain equal, or remain behind the competition. Every company is seeking improvements, but sometime this can be achieved due to the limited resources.

The scale-up is the ratio of the target to the current product. The higher the number, the more effort is needed. The sales point is a measure of how sellable a particular requirement is. If the company considered the best, the sales point will be high. This should be included in the sales literature and training. The sales point column develops marketing strategies.

The weight is a calculation that takes importance, scale-up, and sales point The weight can be ranked on a Pareto chart from high to low. This is then used for development activities. The resources can be allocated to the list in order for priorities.

The next step is to fill the middle part of the matrix. This will lead to identifying the relationships between the customer requirements and the technical requirements. This task usually takes a long time. These relationships are defined as strong, medium, and weak relationships. Symbols are usually used for this purpose.

The bottom of the matrix then can be completed. This is where the company is compared to the competition using all the technical characteristics. Now the team can discuss what the customers perceive and what has been measured. This will result in showing the areas that need to be improved.

The last two rows will be two weights. The first will be weight row, and the second will be a scaled weight. The first represents the total of the relationships in each column. A strong relation is equal 9, a medium equal to 3, and a week equal to 1. This total will show the impact of the technical characteristics on the customer requirements.

The second weight uses the planning weight from the planning matrix with the relationships. Each relationship is multiplied by the planning weight and then totaled. This will show which technical characteristics are most important in meeting the customer requirements.

The last thing to do is to look at the peak of the QFD. This is where the technical characteristics are evaluated against themselves. These are positive or negative relationships. This will identify where trade-offs are occurring.

At this point the foundation for all future QFD matrices is developed. Once the first matrix is developed, the rest of the matrices will develop more quickly. This will follow the same procedures with more abbreviated set of steps.

III.6 Ending QFD process:

A new product development QFD can be ended when the manufacturing feasibility is found. The ability to make the product is a critical step. QFD identifies the major restrictions for making the product. To move beyond that may need a re-direction in the overall business plan.

Staff and service QFDs will end when they complete the scope of the project. This may be better communication, the establishment of routine customer feedback, or the development of quality measure. One team looked at better ways to obtain customer information. The QFD produced some better approaches.

The facilitator and the team leader need to determine when a project ends. This is then presented to the team and the team begins work on a report, which will show the conclusions reached by the team with some recommendations for the next step. This report will be presented to the group of management. This will tell this group of management what the team members think about the QFD process. Management is then decide whether or not QFD is a good tool.

It is also important for the facilitator and the team meet to evaluate the process. This is important of the company expect the QFD process is continually improving. Lessons learned can save time and money , also creating the opportunity for innovation to the QFD methodology.

One use of QFD that is still in the early stages is as a Supplier Partnership tool. When trying to establish Supplier Partnerships, there are some phases that customers and suppliers go through. This can be described as an interpersonal relationship resulting from marriage. The first meeting is like a date. Both parties try to put their best foot forward. When an initial contract is made, this is the going steady phase. Both parties are making a limited commitment to see if the initial impressions are true. Engagement occurs when longer-term contracts are made based on past performance. Marriage happens with the long-term contract and the invitation to assist in new product development. QFD requires some investment in terms of time and people, but in long run the benefits with better product will achieved.

IV ROLES WITHIN THE PROJECT TEAM

IV.1 Introduction

This paper will discuss the application of Concurrent Engineering (CE) within the Project Management (PM) environment. Specifically, the topic of discussion will be the combination of CE and PM as applied in product development.

Project management and concurrent engineering are essential elements of successful product development. CE and PM are not separate entities. In fact, concurrent engineering can be thought of as a subset of project management.

With CE the customer, or specifically the customers' satisfaction with the product, is key. Concurrent engineering focuses on customer satisfaction through some of the following techniques:

-Provides direct communication between the customer and project team. This helps prevent "marketing bias" which distort the companies view of the marketplace. In many companies, marketing tends to focus on personal opinions or on a limited customer base.

-Defines the product in the customers language, then specifies the technical details using a multi-disciplinary team. This results in more thorough specifications as all "downstream" parties participate in the design process.

-Compares customer requirements to the competition. By using a benchmark system, customer requests can be more easily defined in technical terms. This reduces "over specifying" and giving the customer features that they do not want.

A concurrent engineering environment will differ slightly from the normal project management organization. Some of the following features will be found in a CE environment:

-Project team members work exclusively, or primarily on one project. This can eliminate some of the "two manager syndrome" and priority conflicts that take place in traditional project management.

-Project teams stay together throughout all phases of the project. This can reduce some of the "over the wall" and "not invented here" problems associated with sequential participation.

-The project team is given more power to make decisions. Required levels of authorization are reduced at the project and organization level. Because all affected functional departments are represented, decisions can be made effectively within the project team.

-More resources are applied earlier in the project life cycle. CE emphasizes up front planning, which reduces expensive changes and ramp up of effort in the later stages. The idea is to design the product correctly the first time, reducing changes over the course of the project.

In the sections that follow, some of the topics of concurrent engineering in project management are discussed. First, the roles of the project team are evaluated, then compared with an example from industry. This discussion will not detail the differences between PM and CE. Rather, the combination of the two, and how CE is applied in project management will be the focus.

Next, the communications infrastructure will be discussed. Concurrent engineering puts an emphasis on communication, both internal (within the team) and external (with customer and associated parties). Communication methodologies and roadblocks will be compared with an industry example.

IV.2 Roles of the Team Members

This section discusses the members of the project group. In most studies on project management, the focus is on the role of the project manager. This discussion will focus on the roles the primary team members. In a way, the role of the project manager can be defined as the collection of the roles of the project team members. Her job is to facilitate, coordinate and enforce these roles.

The roles described here are a composite of studies from project management and concurrent engineering. The roles of Design Engineering, Marketing, Manufacturing, and Purchasing will be discussed. Other team members are defined in current literature, such as Contract Administrator, Controller, Accountant and Field Project Manager. These roles have significant overlap with the function of the project manager.

IV.2.1 Design Engineering

In traditional project management, the function of the design engineering group in is to develop sufficient documentation and specifications so that the product can be manufactured within quality and cost constraints. These responsibilities are similar in a concurrent environment. Through CE, the effectiveness of the design group can be enhanced by focusing on these areas:

-Insure that the customer needs are met. This requires an understanding of the customers requirements (which should come from direct communications with the customer) and the capability of the company to meet those requirements.

-Define the customer and product requirements to the functional areas, such as manufacturing and purchasing, so that proper scheduling and quality can be met.

-Provide technical direction and leadership for the project. This includes reviewing designs with the customer and other functional groups, defining customer and product requirements, and providing technical support where needed.

During the Conception phase of the project, the design engineering group should work closely with the customer and the marketing group to define the product. In most projects the design group performs feasibility studies and estimates cost, time, and resource requirements. All preliminary information, such as performance specifications, should be shared with the other team members. By involving the other team members early, downstream problems can be eliminated.

During the Design phase, the group is most heavily involved in converting customer requirements in to specifications. The technical details of the project are specified and documented. Communications with the customer should be maintained at this stage. All details should be communicated to the customer on his terms, and to the functional groups on theirs. It is important the customers needs are not lost in technical jargon.

During the acquisition phase, the design group is responsible for communicating and documenting all change orders. It is also responsible for validate the product, to specifications of both the customer and engineering. It should stay in contact with the customer, while keeping customer requirements in mind as design modifications evolve.

During the operation phase, the design group can improve the organization by providing information for future projects (termination report). This should include feedback from the customer and project team.

IV.2.2 Marketing

This group is often under-emphasized in the study of project management. This is probably because these studies tend to focus on the execution of project management techniques. Marketing is most heavily involved in the conception phase and earlier, which is not a large part of project management theory execution.

In a typical project management organization, this group is responsible for new product conception. This includes providing preliminary financial information, determining marketing and sales strategies, and generating the project proposal.

The marketing group is the closest to the customer, and therefore strategic in the concurrent environment. By maintaining significant customer contact this group can insure that his requirements are met.

Communication is the vital link that this group provides. An effective marketing organization will define the product in customers terms and communicate them to design engineering. The opposite is equally important, translating technical details from engineering to the customer. Maintaining a good working relationship with the customer plays a big part in project success.

IV.2.3 Manufacturing engineering

The primary responsibilities of this group are to plan, implement and monitor all manufacturing aspects of the project. This requires coordination with the various manufacturing departments, design engineering, and purchasing.

Some of the specific functions include cost estimates, training, evaluating processes, build reviews, documentation, product release, and parts procurement. Most aspects involving the transition of the project from engineering to production go through this department.

This group should plays an important role in a concurrent environment. It provides the link between production and engineering. In a concurrent environment, this group is the manufacturing liaison to the project. It should have direct communications with the customer. In this role, it can help the project continue to meet customer requirements throughout the life of the project.

During the project conception phase, this group gives preliminary information on manufacturing techniques and organizational capacity. It also provides estimates on production cost, resource requirements and so on. During this phase it is important that the manufacturing group understands the customers needs, so that his requirements are not lost in the transition from design to application.

During the design phase, this group reviews all designs for manufacturability and compatibility with the organizations capabilities. This will include review of all documentation to build and assemble the product. It will also include review of documentation and implementation strategies for all design changes.

During the acquisition phase, this group is responsible for the transition of knowledge from design to production. This includes release of drawings, training, and product test requirements.

During the operation phase, this group is responsible for product support.

IV.2.4 Purchasing

This group is generally responsible for all contract and vendor relations. In most product development projects, this group performs the functions of vendor selection, material acquisition, contract negotiation and supervision, and production inventory control. It maintains contact with vendors and contractors throughout the project life cycle.

Like the other functions, purchasing can contribute to project success. Some of the areas where purchasing can contribute to the concurrent effort are as follows:

-Provide information on vendors early in the conception of the product. By "steering" the project towards known reliable suppliers some downstream problems can be eliminated.

-Involve vendors in the conception, design and development stages. Often vendors posses knowledge that the organization lacks, which can be utilized effectively and often inexpensively.

IV.3 Results of Survey on Roles

A survey on project development roles was taken at Althin Medical Inc, Portland Oregon. This company utilizes project management and concurrent engineering techniques in the development of medical equipment. The company organization is a weak matrix. Functional managers maintain much more power and authority than project managers. The project manager usually performs more of a project coordinator role, where major decisions are made within the traditional hierarchy.

Representatives from upper management, design engineering, quality assurance, manufacturing engineering, and production responded to the survey. Unfortunately representatives from field service, marketing, and accounting did not respond.

The format of this part of the survey was similar to a Role Clarification Technique (RAT). Althin suffers many of the problems surrounding poor role definition. These include misunderstandings about role assignments, the project purpose, and group interaction conflicts.

The survey began with an introduction of a "generic" product development project, in which all groups played an active role. This model was to be used as a baseline for completing the survey. The participants were instructed to consider themselves, or their group as a whole when responding to questions, and to consider the project life cycle.

Unlike most surveys of this kind, the questions were broad based and participants were encouraged to elaborate on their ideas, experiences, and opinions. The purpose of this format was to gain an understanding of the way people view project management and concurrent engineering. These questions about role understanding were asked:

1. "What are the roles and responsibilities of your group within the project, and within the organization?"

2. "What are the roles and responsibilities of the other groups within the project, and within the organization?"

Results of the survey showed that these questions should have been more concise. However, some good information was obtained. The following is a summary of responses to question #1:

-Most answers to this question tended to be somewhat generic. For instance, design engineering mentioned "design to specification" and purchasing mentioned "offer alternative suppliers." It demonstrated that participants had a good understanding of their traditional roles, and that the roles were consistent with the role definition section of this report.

-Some of the responses indicated a stronger than expected concurrent environment. Several participants mentioned that working with other functional groups was a key role. For instance, one of the responses from purchasing was "Work with suppliers and engineering to make sure that the product manufacturable and specification are acceptable."

-Some of the responses from upper management indicated a strong concurrent environment. These included "Making sure that the project is a strategic match for the business" and "Maintain focus - make sure that competing projects do not intervene."

-Other responses indicated a good understanding of concurrent practices. These included "Support the project through the entire life cycle", "Assure specification and processes are developed with consideration for measuring and monitoring where required", "Keep in mind how design will impact other groups", and "Product must be developed with a well defined and documented process."

Responses to the second question hinted that is was far too broad based. Rather than asking for role definitions of all project team members, participants were encouraged to elaborate on a few of the roles they felt were significant. The following is a summary of responses to question #2:

-The majority of responses indicated a good understanding of traditional roles. None of the responses indicated a lack of understanding, and most were consistent with the role definition section of this report and question one.

-Concurrent engineering concepts were mentioned a few times. For instance, upper management mentioned that the materials group should "Involve the supplier base early." Quality assurance mentioned that all groups should "Stay abreast of new technologies" and "improve quality and reliability, and reduce cost."

-One aspect of the survey was somewhat of a suprise. None of the participants discussed how the roles of the other groups affected their own groups. I expected some discussion on how the groups interacted. This was unexpected, as I thought most people would describe other team elements by association.

The lack of depth to the previous questions was anticipated. Therefore, in order to further enhance the understanding of team roles, two additional questions were presented. The questions were aimed at uncovering some of the more intimate aspects of team interaction. These questions were:

3. "What are the strengths and weaknesses of your group?"

4. "What are the strengths and weaknesses of the other groups?"

These questions helped identify some of the information not obtained in question #2. The participants considered these questions more probing. Several chose not to answer question number four.

In general, most responses listed functional specialties within groups as strengths. Lack of teamwork, training, and an understanding of the project as a "whole" were mentioned several times as weaknesses.

Some of the comments on weaknesses revealed poor role understanding. The following are examples:

-Upper management mentioned "lack of project management skills" as a weakness in the design engineering group. This group also mentioned lack of teamwork as a weakness within its own group. With the weak project management structure, a lack of teamwork in upper management can be a major cause of poor project management.

-"Weak listening skills" and "Don't keep others informed" were mentioned. These show not only a lack of role understanding, but a communications problem as well. If the team members do not communicate well, concurrent ideas and application fall apart. Roles can not be well understood with poor communication within the team.

-"Too limited a perspective", "Not well integrated with the group", Lack of knowledge of technical aspect" and "Re-active rather than Pro-active" were also mentioned. The context of these comments also indicate a lack of role understanding. They show that groups don't fully understand the responsibilities and methods of the other groups.

IV.5 Communication Within the Project Team

This section discusses communication within the project team. Communication is major factor in the concurrent engineering environment. A concurrent team relies heavily on person-to-person communication within the project team. Lack of efficient and effective communications can lead to project failure.

In most product development projects, there exists a communications infrastructure. The infrastructure is any system, equipment and software that facilitates the meaningful transfer of information relating to the project. It will determine the degree to which data from various disciplines can be meaningfully organized and accessed.

A system can be manual, interpersonal, or computerized. Interpersonal and manual systems are usually found only in very small projects and organizations. It will usually take on the form of conversations, memos, and meetings.

Concurrent engineering techniques suggest that a computerized system be used. This system can utilize E-mail, databases, reporting systems, and "Knowledgebases." These systems are inclusive, meaning that the higher level systems include all lower level systems. For instance, a system that uses E-mail and databases will also include meetings, memos, and conversation.

The level of technical in the infrastructure should correspond to the level of effort and complexity in the project. As the number of participants in the project increase, the number of communication paths increases exponentially. Therefore the more complex systems are most effective in large project groups.

IV.5.1 Barriers to Communication

Even with an effective communications infrastructure, the project team must overcome many communications barriers. Most of these involve person-to-person communications. A summary of barriers are:

- Receiver hears what he expects to hear
- Sender and Receiver have different perceptions
- Receiver evaluates the source
- Receiver ignores conflicting information
- Words have different meanings
- Non-verbal cues are ignored

These barriers can be overcome if proper understood. The key to overcoming barriers is to not assume that the message you sent will be received in the form it was sent. Below are a few elements to good communications:

- Feedback
- Many Channels
- Face to Face communication
- Sensitivity to receiver
- Careful timing
- Reinforcing words with action
- Simple language
- Redundancy
- Common Vocabulary

Effective communication begins at the personal level. The following hints are valuable in developing good interpersonal communication:

- Think through what you wish to accomplish
- Pre-determine the way you will communicate
- Appeal to the interest of those affected
- Give playback on what others communicate to you
- Get playback on what you communicate
- Test effectiveness through reliance on others to carry out requests

IV.5.2 Results of Survey on Communication

In addition to the survey questions on team member roles, two questions were presented on communications. These questions were:

5. "How do you communicate to the other groups? Is it effective?

6. "How do the other groups communicate with you? Is it effective?

The purpose of these questions was to gain an understanding of the effectiveness of project team communications. Most participants combined these questions in to a list of communications methods and commented on their effectiveness. The following is a summary of those responses:

Meetings:

"Can be effective when agendas well thought out and followed."
"Not always the best method - other forms of communication would be better."
"Could be more effective."

Verbal:

"Listening skills are the most important."
"Allow problems to be resolved quickly."
"Best way to review status - individually"

E-Mail:

"The fastest way to provide information."

"Being used more and more throughout the company."

Memos:

"Used mostly as a tool for formal documentation as required."

In general, most participants thought that existing communications were effective a majority of the time. Many took this opportunity to comment on problems involving communications. These comments are interesting in that many indicate not only communications problems, but systems problems as well. The following represent some of these problems:

"The biggest problem is that you may not find out a critical piece of information when you need to know it."

"Don't trust the system."

"Don't have a good process. Most engineers are not receptive to input on manufacturing issues."

"We need to do some training - we need to present some basic guidelines."

"Design engineers don't normally ask for input. There needs to be a process that puts groups at an even level."

"Most communications is reactive and not planned proactive."

"It is about 70% effective. The reason it is not more effective is because engineering projects do not use formal project management."

"Typically, people are notified only after dates have been missed."

"Typical situation is to talk out the problem with only those who can fix it, but not involve all the right people."

"The major problem with the product development process is a lack of understanding of specifications from marketing to engineering."

IV.4.6 Conclusion:

This report investigated project team member roles in a product development project, and how concurrent engineering practices can enhance those roles. The results of the investigation were compared to an example company through use of a survey. The company is in the process of developing project management and concurrent engineering methods in product development.

Results of the survey indicated a fair understanding of CE and PM methods, but a great deal of systems problems still exist. While some areas of the company understand and use CE and PM, other areas are lagging behind. The company is in need of significant training to complete the transition to PM and CE.

A number of the systems problems were detected through responses to survey questions on communications. These helped uncover the lack of teamwork, direction and understanding of PM and CE.

The overall results of the survey were not as anticipated. I expected a stronger communications base, and a weaker understanding of roles. It appears from the survey results that the various functional groups are well aware of the roles of the other groups, but serious communications problems exist. A program is needed to educate employees on progect management, and improve communications.

V Concurrent Engineering Examples:

V.1 Mazda's decade of experience:

Mazda adopted the task force concept many years ago- in 1978. At that time, it was recovering from its near bankruptcy in the first energy crisis and was looking at ways to ensure that its future models were in tune with what customers wanted, or might want if conditions changed. In other words it saw the task force approach as one plank in its rejuvenation program.

This was no surprise, because Mazda's troubles in 1974-75 stemmed from its decision to give priority to the development of the Wankel rotary engine, despite the product's poor gas mileage and unreliability. Demand was so poor that Mazda sent many engineers out to work temporarily in its sales office and at its dealers. In trying to sell the huge stock of rotary-engined cars, they found that many customers were simply not interested in what type of engine was under the hood. They wanted a compact, economical, and practical car. Mazda realized it needed to listen carefully to its customers, and so it embarked on the development of the first GLC hatchbacks. Later on, Mazda adopted a flexible approach based on a multidisciplinary task force, with around 15 people being involved at the start of the project. When a particular problem is encountered or a critical stage reached, additional people are brought in for a few months. Usually, the project team remains in charge of the vehicle until production starts.

However, the team leader, who is an engineer from R&D, remains responsible for the model as long as it is in existence, or until he or she is assigned to a new responsibility. Generally, the team leader will remain responsible for the vehicle throughout development and production, and if a new job is to be assigned, the handover takes place when the succeeding model is at preconcept stage. This is closer to the "profit center" approach of some American corporations, where the task force is responsible for the success of a product from preconcept to retirement.

Thus, Mazda's main thrust is in the use of a task force, although it does use QFD in the development of new models. In some cases, however, it relies on the project planner's knowledge instead of the customer's voice. Mazda has also used Taguchi in a few instances but has yet to adopt it as a matter of company policy or specific purposes. Nor does Mazda involve any vendors of components or machine tools in its task force. To ensure that they remain close to the project, it puts someone from purchasing on the team, and this person works closely with vendors. With its task force system, Mazda has been able to speed up the development of its new model programs. Overall, the development of a new model from the decision to start the project to production takes about 42 months. The first 18 months are spent taking the initial idea to approval by management of the clay model. An additional 24 months is needed to take the concept to production.

V.2 Nissan Takes Up CE:

In an attempt to overcome the weakness of its product line at the time, Nissan adopted CE as a discipline in January 1987. Nissan had been losing market share in Japan for several years, and had also suffered a massive internal political row over whether it should build a plant in the United Kingdom. CE was adopted as a means of raising the company from its poor position. Since then it has been able to identify a few niche markets and to open them up successfully well ahead of Toyota, partly as a result of CE.

In adopting CE, Nissan set up a product and market strategy office to determine demand trends. It is responsible for planning the company's product lines, power trains, and marketing. There is a product planning and marketing group, with one task force for each model. The task force includes members from production, quality control, and testing. In addition, at the beginning of each project and at times during its progress, other specialists join in meetings. Like Toyota, Nissan places control firmly in the hands of product engineering, but unlike Toyota, it includes members from other departments in all projects.

Now that Nissan has established CE in Japan, it is extending the technique to its operations outside Japan and will adopt the approach at its overseas engineering centers. Indeed, the company considers CE essential because the structure of industry in the West differs from that of Japan.

It has therefore started a program to explain to vendors how it develops products and how it wants vendors to become involved. It is requesting major vendors to increase the amount of design, development, and testing carried out in-house. In other words, it is attempting to persuade them to operate more like Japanese vendors. It has also adopted CE for projects outside Japan with multifunctional teams in control from the start. Significantly, it wants its vendors to be more flexible than they are at present, by creating an environment capable of managing frequent change. This of course is one of the essential features of any successful management approach.

To foster the development of the best of new manufacturing and product technologies for use in all its vehicles, Nissan also established a concurrent engineering center in 1988. Among its personnel, 30 percent were drawn from product engineering; 30 percent from the central research laboratory; 15 percent from the styling department; 15 percent from the assembly plants; and 10 percent from the test and prototype sections.

This is a new approach, since the work is applied R&D, an area where production engineers are rarely involved, and if they are, their role is that of advisor rather than full team member. At Nissan, all member of the teams work as equals, so the breakthrough required in these new technologies are more likely to be achieved here than in corporations that carry out the work behind closed doors in an R&D department staffed entirely by product-design-oriented personnel.

V.3 Honda's decade of expansion:

Honda adopted CE wholeheartedly in a manner that resembles the Western approach. Honda was one of the first to adopt CE anywhere, with its SED (Sales, Engineering, Development) system of product development. Honda does not call its system concurrent engineering; when the then president Kiyoshi Kawashima introduced the SED system into Honda in the late 1970s, concurrent engineering was not even recognized as a methodology. But that is just what SED is-a product development team combining sales, engineering, and development division members.

Kawashima wanted Honda to be able to respond more quickly to customers' requirements and to competitors' moves, and sought improved quality. It was decided that a multidisciplinary task force approach was needed. At that time Honda was a relatively small Japanese carmaker, building the Civic, Prelude, and Accord car ranges and some lightweight trucks. In 1980 it produces 956,900 vehicles, including 107,000 light trucks, all in Japan. It was also having difficulty breaking into the market for automobiles with engines bigger than 1.3 liters in Japan, because the general public saw Honda as a maker of motorcyles, so durability and reliability were not considered important.

V.3.1 Unparalleled Seller in the United States:

Ten years later, Honda's reputation as a manufacturer of high-quality automobiles is secure, and output has more than doubled to two million units a year, one-third of which are built outside Japan. Its market share in Japan has increased sharply and sales in the United States have grown to an amazing 855,000 units-equal to its total passenger car production in 1980 and just 6,00 units below Chrysler's sales. The Accord was the best-selling car in the United States in 1989 and 1990, while Honda's U.S. output was over400,000 units. Moreover, Honda sold about

80,000 more cars in the United States in 1990 than Toyota, despite Toyota's worldwide production of around four million vehicles a year.

As a result of its use of SED, Honda has been able to expand the range of cars significantly, and add many derivatives. It now produces the following ranges of passenger cars:

Today midget car and beat midget sports car

City minicar three-door hatchback.

Civic range of two-door sports coupe, three- and five-door hatchback, and four-door sedan.

Concerto four- and five-door sedans.

Integra three- and five-door hatchbacks and two- and four-door sedans.

Accord four-door sedan, some with transverse four-cylinder and some with in-line five-cylinder engines, and two-door coupe (the coupe is built in the U.S, and some are exported to Japan).

Prelude two-door sports coupe.

Legend four-door sedan and two-door coupe.

NSX two-door mid-engine super sports coupe, produced at the rate of around five thousand a year.

Not only is this a substantial range of vehicles, but in line with the Japanese tradition, most are rebodied at four-year intervals. In addition, during the 1980s, Honda produced new engined for all its existing engine families and introduced two extra engine types-an in-line five-cylinder for some versions of the Accord and the V-6 units for the Legend and NSX. If that was not enough, Honda engineers devised an innovative four-wheel steering system, their own anti-lock braking system-first introduced in the early 1980s-an electronically controlled fuel injection system, and a four speed automatic transmission, and was able to produce and maintain world-beating Grand Prix engines for most of the decade. The extent of the expansion, and the range of successful technical developments made by Honda without reliance on vendors to develop systems for it, is unparalleled in the period. Were Honda to have used over-the-fence engineering, the work load would have been too great, and some of the developments that helped fuel the expansion would have been impossible.

Honda SED, which has been the key to the corporation's remarkable success in the past decade, symbolizes the three main divisions within Honda:

Sales, including service

Engineering, for Honda Engineering, the company that makes manufacturing machinery and tools.

Development, for Honda Research and Development, which is responsible for all new product development.

Each division provides members of a team responsible for engine, transmission, body, and chassis, while the Research Division of Honda R&D provides input on new materials and technical developments.

What progress has Honda made in shortening its new model lead time with the aid of SED? It has reached the stage where the complete project from preconcept to production takes 32 to 36 months, and it intends to reduce this to 24 months in the next few years. That Honda can achieve such a timetable is borne out by the fact that when it worked with the Rover Group on the 800 and 200/400 series, it was able to start up volume production 12 months ahead of Rover, even though the initial concept work and much of the detailed design for Honda and Rover models were done at the same time. In addition, Rover had by that time made a lot of progress in reducing lead time as well-although it started from a lead time of 6 to 8 years.

V.4 Electronics Manufacturers:

Matsushita Electric Industrial, the huge company behind the Panasonic name, is at a relatively early stage with conscious CE, but has been using a number of elements for some time. Sales agents have direct contact with the design department, so that the voice of the customers is strong. Like many Japanese corporations, Matsushita has concentrated on reducing lead times in production.

There is considerable overlap in the periods when product design and engineering of the production system are carried out. In the case of a project to build industrial controllers, the production engineers started designing their equipment after the product designers had only been working on the project for 2 months-one third of the way through this particular design project. The plant was built in less than 6 months, and the manufacturing equipment was developed over a 12-month period, including the time the plant was being constructed. Improvement of the manufacturing process continued for another 12 months, during which time pilot production was undertaken.

These controllers consist of sheet metal housings and electronic assemblies. Matsushita operates on a six-day order-to-delivery cycle, with the first two days being taken up in sales and administration. On the third day, the CAM (computer-aided manufacturing) data are verified and the schedule is determined. Production takes place on the fifth and sixth day, and the assembly is shipped immediately. This speedy response is another facet of the Japanese approach that is setting the standards in terms of one aspect of customer satisfaction.

V.5.From Laggards to Leaders:

Those that do make the move to CE will find that there are plenty of role models to follow. Some of the greatest success with CE has been achieved in the electronics industries. Two outstanding examples are Xerox and Digital Equipment, both of which needed to make urgent changes if they were not to lose their position in their markets. Significantly, both corporations operate worldwide, with manufacture in several ares; thus they were, and are, closely in tune with world markets.

Xerox, which had milked the cash cow of xerography for well over a decade, found itself losing market share dramatically in the late 1970s. The market was being lost to a number of Japanese companies such as Canon and Ricoh, and the information coming back to the corporation suggested that poor quality was the main problem. Faced with this situation, Xerox decided improved quality was of paramount importance and that it therefore needed to adopt a new technique for developing products. Initially, only a few of the concept of CE were taken on board, but as problems were encountered the system was modified, with new training modules being added-proof that once you move to CE you will stick to it.

Digital Equipment was also in a plight when it first took up concurrent engineering; it needed to do something drastic if it was to turn its entry into the workstation market into success. When it decided to enter the market, it had assumed that a good product based on the latest technology would have a long life and be profitable. That proved to be completely wrong: the demands of the market were continually changing, so product life was short. It also found that more derivatives were required, and that the 30-month lead time resulted in a poor return on investment and a late break-even point.

To overcome these problems, it adopted CE in 1986-87, and as a result came back to take a substantial slice of the market-and make money. So, here are two examples where lagging companies were turned into leaders with the aid of CE. That both are large corporations is proof that the culture of an organization can be changed as long as the senior management has the will and imagination to do so.

Xerox started on its product delivery process (PDP), which is CE under another name, in 1980 and has modified it many times since. Its situation was one that frequently occurs in corporations that grow rapidly with tight grip on new technology. Xerography changed the way in which businesses operated, and so the market grew at a tremendous rate. In such organizations, growth tends to race ahead of the systems needed to support the enlarged corporation. Xerox was suffering from its success. Design was lacking the discipline of systems, a situation exacerbated by the fact that even now, the xerography process is not understood in complete details. Also, there was not enough reliable information coming back from the customers-despite the fact that the copiers were normally leased.

Xerox had placed itself in a classic situation: the product was rushed into production too quickly in order to match competition, and as faults were encountered by the long-suffering customers, the changes came through. In fact, every single component of its main office copier products of the 1970s was redesigned after the machine had been introduced to the market. To update the machines, Xerox had a huge army of field engineers-not service engineers-who went out visiting customers to replace the poorly designed components with improved versions. Of course, because the copiers were mostly leased at that time, the cost was borne nominally by Xerox.

Senior management at Xerox realized there was no easy way out to rectify this problem, improve quality, and regain their lost market share; the competition-by then almost entirely from Japan-was too good. They made good quality and customer satisfaction top priorities, and that led to the adoption of the product delivery process (PDP), which is now concurrent engineering through and through.

Xerox has used CE to pull itself up so that on its measure of customer satisfaction, the average for its products has increased from 50 percent to 90 percent; the corporation has a target of 100 percent for all products by 1993.

Typical of the products developed by PDP are the 5028 copiers, one of the big-volume products. Because of problems the corporation had encountered with designs that could not be made easily, one aspect of the team approach in the development of that machine was to force design engineers onto the shop floor, somewhat along the lines of Honda techniques mentioned earlier.

With the aid of PDP, time-to-market has been cut 30 to 40 percent, while some 75 percent of products that go through the concept stage reach the market, a far higher figure than was the case previously. This is of major importance, of course, since when a product is abandoned, considerable design effort is wasted.

Significantly, Xerox operates PDP on a worldwide basis, which includes Rank Xerox, its joint venture in the United Kingdom, and Fuji-Xerox, the Japanese joint venture between Rank Xerox and Fuji group. The system is highly structured and built around a number of modules-over the years the system has been modified many times-but it is extremely close to CE in concept. The most recent modules cover aspects of product delivery such as the launch onto the market.

Conclusion

Concurrent engineering is a subset of traditional project management. It is used to enhance project management in product development projects by focusing on the customer, quality, and time to market. CE can minimize development time and improve quality, which result in substantial cost savings.

Weaknesses in traditional project management can be minimized through CE. These include interdepartmental dysfunctionality which causes delays in product introduction, and poor quality as a result of late design changes.

QFD is a management tool which enhances project and product planning. It relates directly to concurrent engineering concepts. The description, benefits and application of QFD have been presented.

The roles of the team members in a concurrent product development project have been defined. Team roles can be enhanced by focusing on the customer, vendors, and teamwork. A survey was taken at one company and evaluated for CE and PM methods. Results showed that the company is gaining a good understanding of the concepts, but does not have a fully concurrent system.

Examples of successful implementation of CE techniques and task force management have been presented. Japanese auto makers have been extremely successful over the last few decades. Much of this success can be attributed to concurrent engineering.

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