



IIT KHARAGPUR



NPTEL ONLINE
CERTIFICATION COURSES

AUTOMATION IN PRODUCTION SYSTEMS AND MANAGEMENT

Product Development Process and Automation

PROF PRADIP KUMAR RAY

DEPARTMENT OF INDUSTRIAL AND SYSTEMS ENGINEERING

IIT KHARAGPUR

Product Development Process and Automation

- **Lecture-1:** Product Development Process: Approaches and stages
- **Lecture-2:** Mathematical Models for Interaction between Design and Manufacturing
- **Lecture-3:** Sequential and Concurrent Engineering Approaches for Product Development
- **Lecture-4:** Characterization of Concurrent Engineering Framework
- **Lecture-5:** Concurrent Engineering Techniques

Product Development Process and Automation

- ✓ **Product Development Process: Approaches and stages**

Product Development Process and Automation

- The product development process in a company is one of the important activities that is primarily responsible for its long-term survival and sustainability in the market.
- The entire process of product development consists of several steps to be followed in sequence in traditional approach.
- This process is shown in Figure 1.

Product Development Process and Automation

- This process typically requires that the persons involved may be able to communicate freely and effectively among themselves regarding matters such as data collection, problem solving, and suggestions for improvement in products, processes, and manufacturing.
- The main objective is to improve communication between the manufacturing, the top management group, the designers, the suppliers, and the customers on a continuous basis.
- To become successful in product development in the long term, the company is required to establish a collaborative and multidisciplinary approach for product development.



Product Development Process and Automation

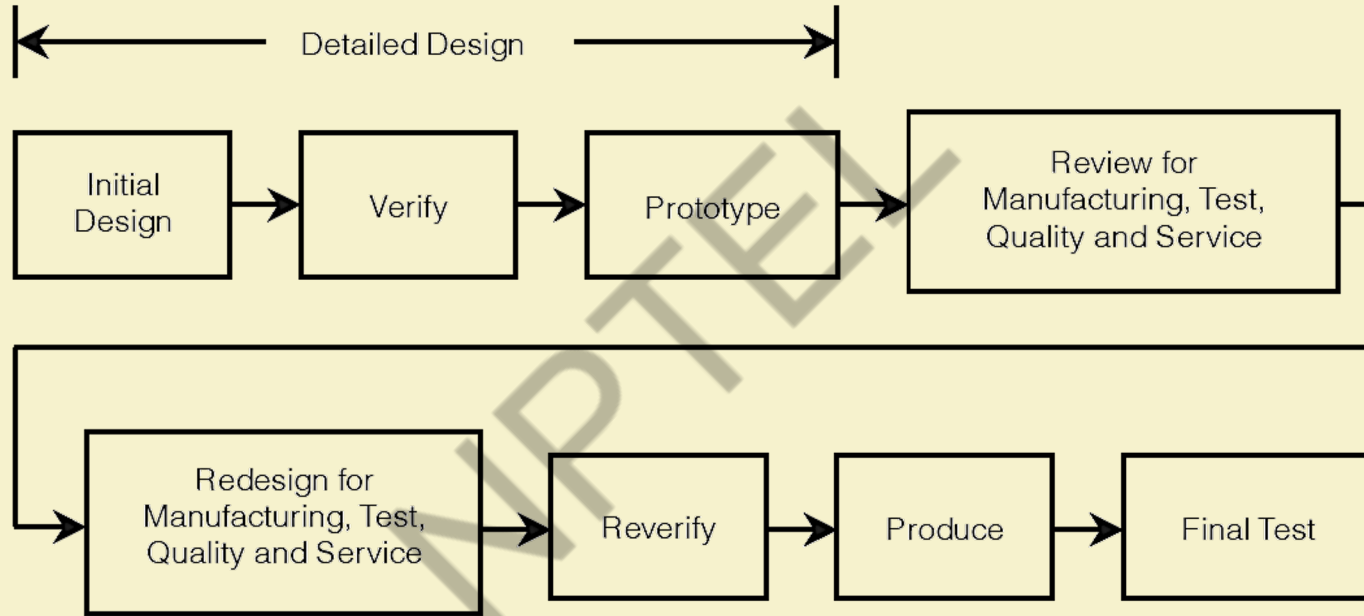


Figure 1. Traditional Product Development Process

Product Development Process and Automation

- A **collaborative approach** may be defined as “the process of people working in teams to pursue design innovation” in which information, ideas, and problem solving approaches are actively shared among the team members.
- This approach may be either **synchronous or asynchronous**.
- In a synchronous approach, the team members meet together either face-to-face in one location, or through audio or video conferencing tools when they are located at different places to discuss and decide on various aspects of product development jointly at the same time.

Product Development Process and Automation

- On the other hand, in an asynchronous approach team members separately contribute to the respective aspects of product development at different stages and times, and the coordinator of the team becomes responsible for decision making at different stages of the product development process.
- The following aspects are usually taken care of in a typical collaborative approach:

Product Development Process and Automation

The following aspects are usually taken care of in a typical collaborative approach:

- i. the design objectives
- ii. existing capabilities of manufacturing systems (machine tools, quality standards, etc.),
- iii. changes in the existing designs of the products,
- iv. action steps for improvement in existing designs and initiation for new designs, and motivational issues related to active involvement of the team members.

Product Development Process and Automation

In today's business environment, a number of tools, techniques, and methodologies may be quite useful in design and development of products. Product Development Team (PDT), Concurrent or Simultaneous Engineering (C/SE), and Computer-aided Design/Manufacturing/ Engineering (CAD/CAM/CAE) and Virtual Reality (VR) are a few important methodologies and tools that are being widely used by many companies.

Product Development Process and Automation

Product Development Team (PDT)

- The objective of this approach is to organize the resources of a company into an integrated team for product development that is responsible for designing, producing, and delivering a product or a number of products to the existing or new customers.
- The team is also accountable for delivering a quality product with acceptable performance to customers, and profitability to the company concerned.

Product Development Process and Automation

- The team members are required to manage the resources under their command in order to provide maximum customer satisfaction concurrently meeting the business goal.
- As the team approach is most appropriate when the product development requires knowledge in different disciplines, the team members are usually drawn from several functions, departments, or sections of a company.
- The team approach has the following advantages:

Product Development Process and Automation

- It ensures that the product design is compatible with manufacturing or service capabilities, and life cycle requirements are most likely marketable with a competitive price.
- It helps speed up the whole design process including its delivery and service as an integrated approach through team work.
- It enables communication and collaboration between personnel in different organizations, functional areas, disciplines, and locations at different phases of the product development.
- There may be significant control on the external product cost.

Product Development Process and Automation

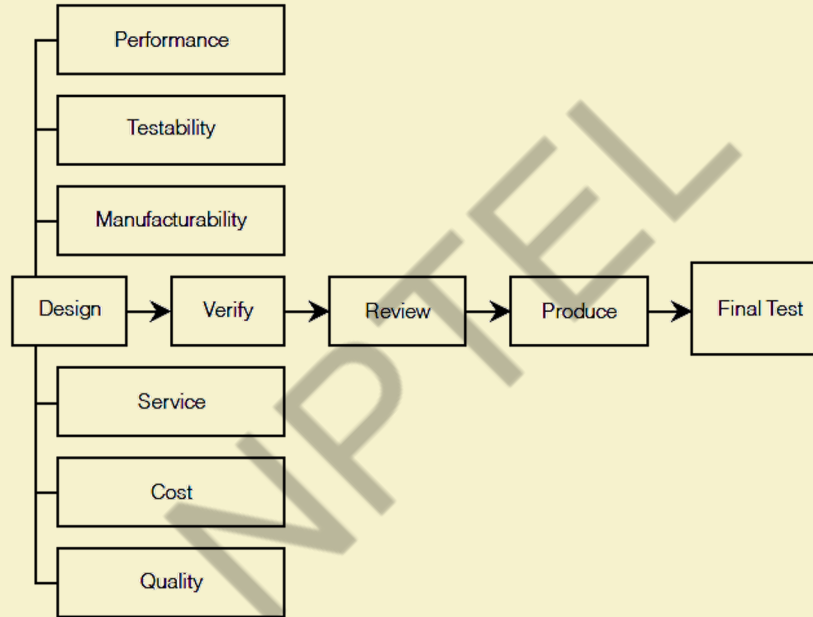


Figure 2. Concurrent Engineering-based Product Development Process

Product Development Process and Automation

To have the best-possible synergy in the whole process, an effective CE approach requires the following conditions to be met:

- The decision models representing the process by which a team gets involved should be flexible in nature.
- The kinds of knowledge to be developed for facilitating design should require integration of several functions.

Product Development Process and Automation

- Appropriate communication system must be in place.
- A number of measurement and assessment tools and techniques (both qualitative as well as quantitative) should be used so that the evaluation of current and new design alternatives can be carried out and made known to all the members of the team.
- C/SE has contributed to a significant reduction in the product development time.

Stages in Product Development Process

- i. **Identification of customer requirements and setting up of design objective**
- It is basically the process of identifying, defining, and documenting specific needs for the development of a new product.
 - The main objective at this stage is to identify, consolidate, and document all the features that the system may have in feasible, realistic, and complete specifications of product requirements.
 - During this phase, a large number of new ideas for the product to be developed are converted into practical requirements and specifications.

Stages in Product Development Process

ii. Identification of design alternatives

- At this stage, identification of several design approaches or alternatives meeting the defined requirements, prior to identifying the best design to be used, is the main purpose.
- This process begins as and when a need for a new product is defined and explained in concrete terms, and ends only when the best design approach is recommended in order to meet the requirements from the new product.
- For this, responsibility should be shared among the members of the design team.

Stages in Product Development Process

- Each member should be aware of the specific design goals and requirements that he/she is entrusted with for their inclusion in the total design of the product.
- Usually, several types of tools and techniques, such as mathematical models, simulation, and trade-off studies are used at this stage to determine the optimum or the 'best' design for the product.
- It is during this phase that the initial producibility, quality, and reliability requirements of the design are documented, and guidelines and action plans are provided.

Stages in Product Development Process

iii. Selection of appropriate design and its detailing

- It is the process of finalizing a product's design which meets the requirements and design approach defined in the early phases.
- During this stage, the product development team may construct prototypes or laboratory working models of the design for testing and evaluation to verify performance results.
- At this phase, the interactions among many disciplines and design professionals take place, and these interactions should be effective.

Stages in Product Development Process

iv. Assessment of product design:

- Assessment of the improved design is done through a series of test and evaluation of the prescribed design resulting in a set of quality features and improved performance meeting the requirements.
- The main goal of this assessment is to identify areas for design improvement for the product, keeping the issues like improved manufacturability and reliability in mind.
- The acceptable levels of the design parameters must also ensure minimum technical risk for the product.

Stages in Product Development Process

v. Manufacturing:

- At this stage, the main objective is to identify the problems (of different kinds) that may be encountered during manufacture of the product as per the specifications of the improved or most appropriate design, and to take corrective and preventive measures to minimize the cost of production and to improve quality of the product.
- The design team is required to perform data analysis using appropriate tools and techniques at this stage.

List of Reference Textbooks

- Groover, M P, Automation, Production Systems, and Computer Integrated Manufacturing, Third Edition, Pearson Prentice Hall, Upper Saddle River.
- Groover, M P and Zimmers, E W Jr, CAD/CAM: Computer-aided Design and Manufacturing, Prentice-Hall of India Private Ltd.
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- ✓ **Mathematical Models for Interaction between Design and Manufacturing**
- ✓ **Numerical Example**

Mathematical Models for Interaction between Design and Manufacturing

Mathematical model serves as a decision support system integrating issues related to design and manufacturing. It address the following three questions:

- How does design affect manufacturing cost, quality, and manufacturing lead time?
- What is the influence of manufacturing process design on these factors?
- How does the concurrent engineering approach help obtain a better solution compared with the serial engineering approach?

Mathematical Models for Interaction between Design and Manufacturing

We consider a simple product, a cylindrical part (shaft).

- a. The design stage is concerned with specifying tolerances on the shaft.
- b. The manufacturing stage is essentially a transformation process, changing a bar stock into a finished shaft meeting tolerance specification.
- c. The process involves a turning operation that can be performed on a turret lathe, an engine lathe, an automatic screw machine, or a numerically controlled (NC) turning centre.

Mathematical Models for Interaction between Design and Manufacturing

- d. The design department specifies the tolerance limits to meet certain functional requirements.
- e. Let t_k^u and t_k^l represent the upper and lower tolerance limits, respectively, for a component shaft for the k th alternative system of tolerances.
- f. Let σ_j and μ_j be the standard deviation and the process mean of the output dimension of the shaft, respectively, for the j th manufacturing option.

Mathematical Models for Interaction between Design and Manufacturing

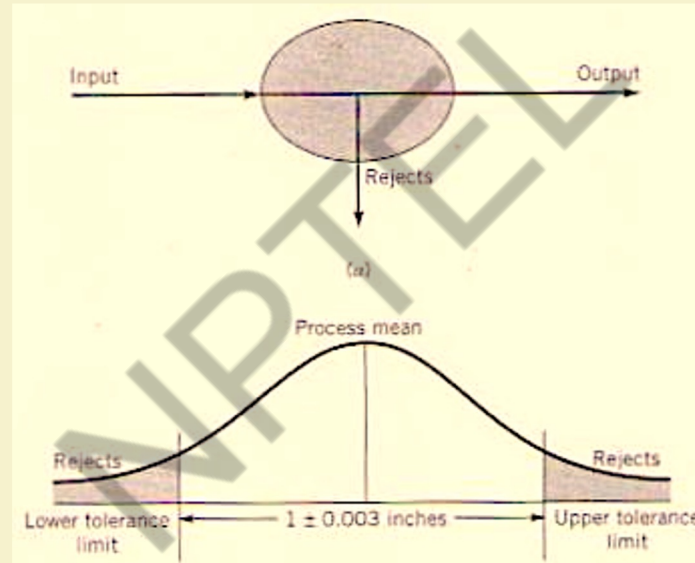
Assuming that the dimensions are normally disturbed, we have

$$t_k^u - \mu_j / \sigma_j = Z_{jk}^u$$

$$t_k^1 - \mu_j / \sigma_j = Z_{jk}^1$$

Where Z_{jk}^u and Z_{jk}^1 designate the standard normal variates for the upper and lower tolerance limits, respectively, for the k th alternative system of tolerances using the j th manufacturing option.

Mathematical Models for Interaction between Design and Manufacturing



(a) The transformation process; (b) normal curve for shaft dimensions

Mathematical Models for Interaction between Design and Manufacturing

- We present a simple analysis without rework. This means that the shaft below the lower tolerance limits and above the upper tolerance limits are scrapped.
- Let Y_{jk}^o , Y_{jk}^i and Y_{jk}^s represent the output, input, and scrap units, respectively.
- We have the fraction of scrap (SC_{jk}) as follows:

$$SC_{jk} = Y_{jk}^s / Y_{jk}^i$$

- At the transformation stage we have the mass balance equation:

$$Y_{jk}^i = Y_{jk}^o + Y_{jk}^s$$

Mathematical Models for Interaction between Design and Manufacturing

- We define the following technological coefficients per unit output to represent the input requirements and scrap generated.

$$k_{jk}^i = Y_{jk}^i / Y_{jk}^o$$

$$k_{jk}^s = Y_{jk}^s / Y_{jk}^o$$

$$k_{jk}^s = SC_{jk} / 1 - SC_{jk}$$

$$k_{jk}^i = 1 + k_{jk}^s$$

Mathematical Models for Interaction between Design and Manufacturing

Material Balance Equations:

- The material balance equations follow directly from the definition of the technological coefficients :

$$Y_{jk}^i = k_{jk}^i Y_{jk}^o$$

$$Y_{jk}^s = k_{jk}^s Y_{jk}^o$$

Cost equation:

- At a transformation process the money inflow rate equals the money outflow rate.

Mathematical Models for Interaction between Design and Manufacturing

These equations provide an analytical model for understanding the interaction between design and manufacturing from the point of view of unit cost of production, quality, and manufacturing lead time.

- The unit cost equation provides the relation for unit cost as a function of design and manufacturing parameters.
- This analytical relationship is helpful in understanding the implications of changes in the design specifications as well as manufacturing technological options for unit cost.

Average Manufacturing Lead Time

- If the average processing time per unit using the j th manufacturing technology is t_j and S_j is the setup time. The average manufacturing lead time (T_j) to produce Y_{jk}^o finished units meeting specifications is given by

$$T_j = S_j + t_j k_{jk}^i Y_{jk}^o$$

- The expected number of defective units produced is a pseudo-measure of product quality.
- Another interesting measure of quality is given by what is known as Taguchi's quality loss function.
- One of the objectives of concurrent engineering is to select the design and the manufacturing process simultaneously so as to ensure minimum possible cost, best possible quality, and minimum possible lead time.

Numerical Example

To illustrate the benefits of the concurrent engineering approach, we propose the following simple problem. ABC company requires 1000 units of a turned cylindrical part (shaft). The design department of ABC company defines a need for a cylindrical part to be finished to 1 ± 0.003 inch. A serial engineering approach and a concurrent engineering solution are presented in the two scenarios that follow. We compare two situations that emerge from these strategies.

Numerical Example

- The design department of ABC recommends a shaft dimension and tolerance of 1 ± 0.003 inch;
- Manufacturing engineering decides to produce the parts on a turret lathe because the desired tolerances can be obtained.
- The process average and the standard deviation are estimated to be 1.00 and 0.003 inch, respectively.
- Other relevant data are: Unit cost of raw material = 10.00, Unit salvage value = 2.00, Unit processing cost = 7.00
- The process engineer determines the unit cost of output, number of units of scrap generated, and number of raw units required to produce 1,000 finished units using the model.

Unit Cost and Scrap Calculations

- As a turret lathe is the first manufacturing technology option, $J = 1$;
- Assuming tolerance 1 ± 0.003 inch as the first design option, $k = 1$.
- For the given data, we get, $Z^u_{11} = 1.00$ and $Z^1_{11} = -1.00$.
- Therefore, from the normal tables, the percentage of items above the upper limit = 15.87 and the percentage of items below the lower tolerance limit = 15.87.
- The total percentage of rejects is $15.87 + 15.87 = 31.74$

Unit Cost and Scrap Calculations

Hence,

- Technological coefficient of scrap, $k_{11}^s = SC_{11} / 1 - SC_{11} = 0.3174 / 1 - 0.3174 = 0.4649$
- Technological coefficient of input, $k_{11}^i = 1 + k_{11}^s = 1 + 0.4649 = 1.4649$
- Number of units scrapped, $Y_{11}^s = k_{11}^s Y_{11}^o = 0.4649 \times 1000 = 465$ (approximately)
- Number of raw units (input) required, $Y_{11}^i = k_{11}^i Y_{11}^o = 1.4649 \times 1000 = 1465$ (unit)
- Unit output cost, $X_{11}^o = k_{11}^i X_{11}^i - k_{11}^s X_{11}^s + k_{11}^i f(Y_{11}^i) = 1.4649 \times 10.00 - 0.4649 \times 2.00 + 1.4649 \times 7.00 = 23.97$

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- ✓ Sequential and Concurrent Engineering Approaches for Product Development
- ✓ Benefits of CE
- ✓ Numerical Example

Sequential and Concurrent Engineering Approaches for Product Development

- Market share and profitability are the major determinants of the success of any organization.
- The factors that influence and improve the competitive edge of a company are unit costs of products, quality and lead time.
- Concurrent engineering (CE) has emerged as a discipline to help achieve the objectives of reduced costs, better quality, and improved delivery performance.

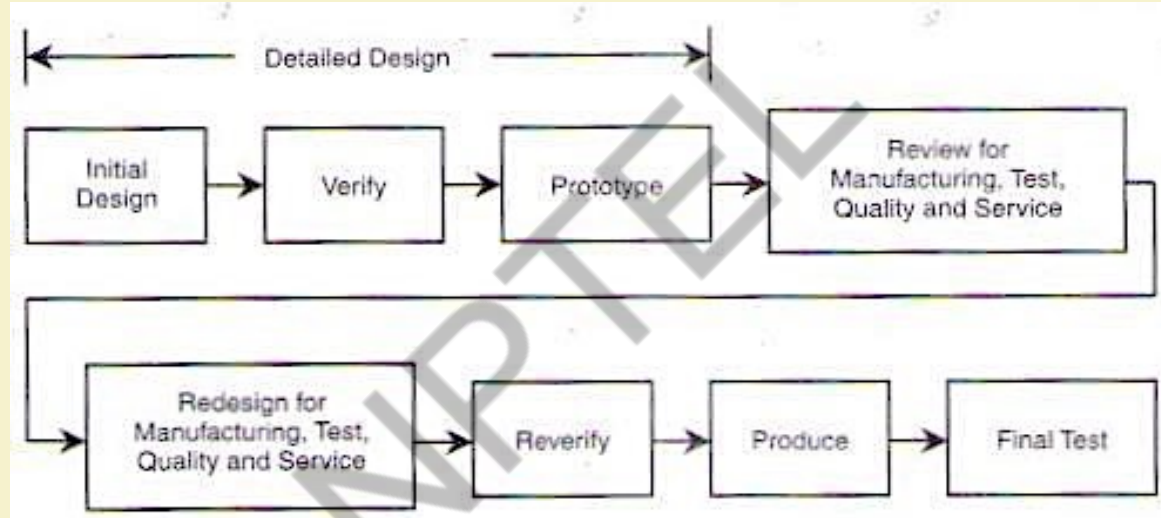
What is Concurrent Engineering?

- 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 conception to disposal, including quality, cost, schedule, and user requirements. (Pennell and Winner, 1989) (US Imitates of Defense)
- Concurrent engineering is a management and engineering philosophy for improving quality and reducing costs and lead time from product conception to product development for new product and product modifications (Creese and Moore, 1990).

What is Concurrent Engineering?

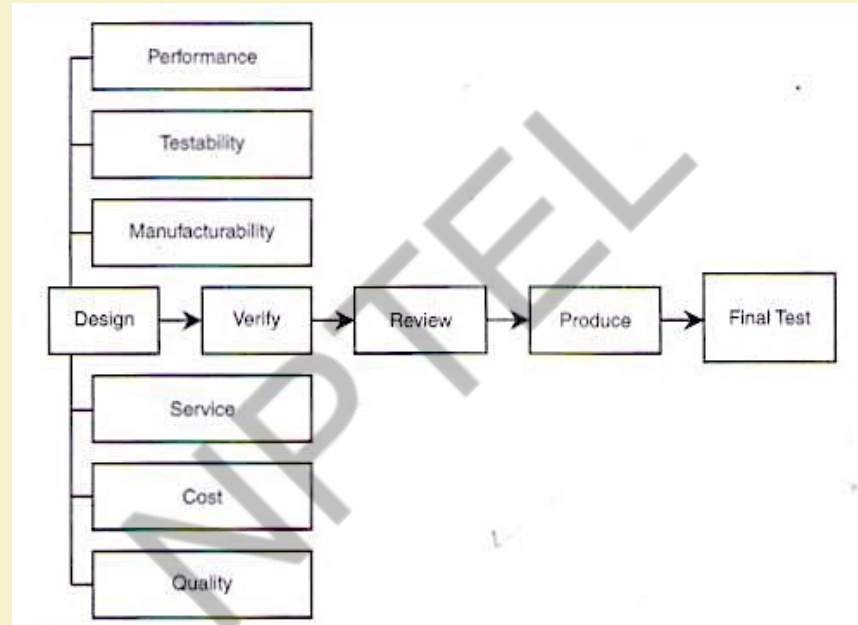
- CE means that the design and development of the product, the associated manufacturing equipment and processes, and the repair tools processes are handled concurrently.
- The concurrent engineering ideas contrasts sharply with current industry sequential practices, where the product is first designed and developed, the manufacturing approach is then established, and finally the approach to repair is determined (Meth,1991).
- Sequential engineering, also known as serial engineering, is characterized by departments supplying information to design only after a product has been designed, verified, and prototyped (Turino, 1991).

What is Concurrent Engineering?



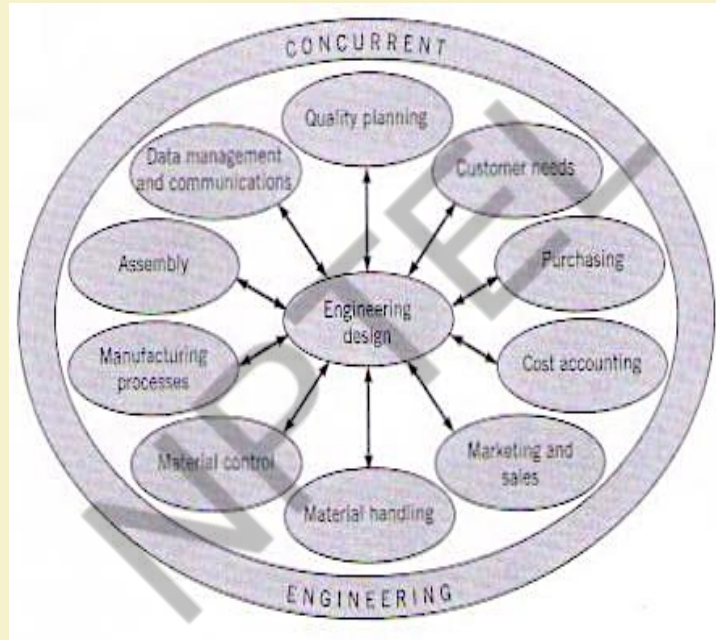
Flow Diagram of the serial engineering organization

What is Concurrent Engineering?



Flow Diagram of the Concurrent Engineering Organization

What is Concurrent Engineering?



Multidisciplinary cross functional focus in a concurrent engineering organization

What is Concurrent Engineering?

- The decision making process in the concurrent engineering environment differs from that in sequential engineering in that decisions are taken considering the constraints of all the stages of the product life cycle at every stage.
- The integration of other functional areas with the design process helps discover hard-to-solve problems at the design stage.
- Thus, when the final design is verified, it is already manufacturable.

Why Concurrent Engineering?

- The present-day market is characterized by increasing product variety and technical complexity, decreasing levels of demand, a discrete product manufacturing environment, expanding global competition, and declining profitability of organizations.
- To survive in such a complex environment, organizations need improved productivity, quality and flexibility.
- What is required is comprehensive, accurate, timely, and readily accessible information related to the design of products, manufacturing and distribution of products, customer requirements, and so forth for effective integration.

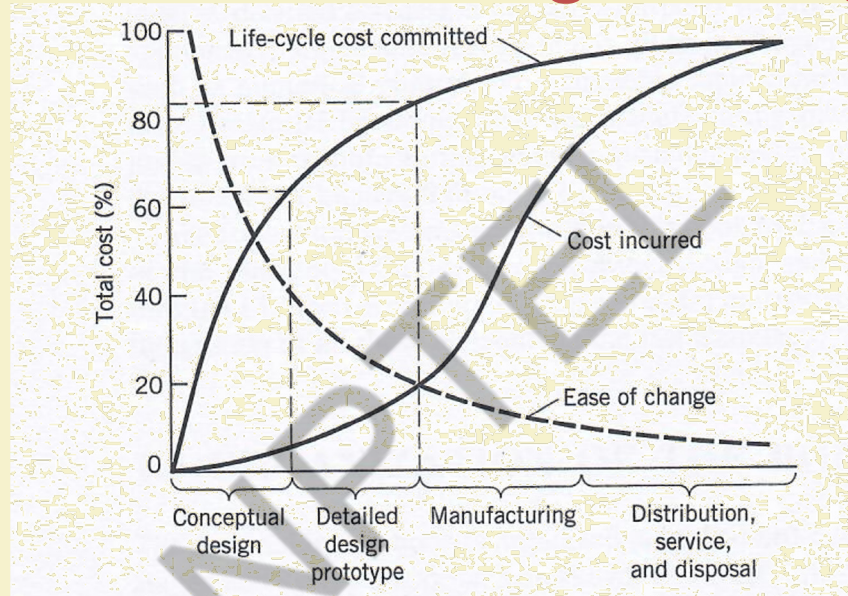
Why Concurrent Engineering?

- Concurrent engineering is a concerted effort to integrate fully the design, analysis, and engineering functions of products and processes.
- The integration results in reduced cost, decreased development time, and improved quality.
- Many studies have indicated that most of a product's cost is fixed early in its life cycle, before the original design cycle is complete.

Why Concurrent Engineering?

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Concurrent Engineering



A characteristic curve representing cost incurred and committed during the product life cycle.

Benefits of Concurrent Engineering?

- Development and production lead times
- Measurable quality improvements
- Engineering process improvements
- Cost reduction

Other benefits

- In many large development projects, especially product development, lack of communication among members of the product development team can lead to extensive engineering design changes.
- Each design change consumes time in the product development cycle. This increases in time to reach market can influence the acceptance of the product, market position, project cost, and quality.
- These issues alone are compelling reasons for a firm to adopt the concurrent engineering approach.

Numerical Example

Concurrent engineering is based on cross-functional and multi-disciplinary teams representing various functional areas.

Multifunctional team is responsible for addressing various issues:

- i. The marketing services of ABC found that the tolerance range of 1 ± 0.003 inch may be too tight.
- ii. The quality department did not like the number of rejections.
- iii. The manufacturing planning department wants to use machine tools with better process capabilities.
- iv. The purchasing department cannot buy so many raw shafts because of the restricted availability of such steel.

Numerical Example

- The team begins by agreeing to hold the shaft dimensions to 1 ± 0.003 inch.
- The manufacturing departments recommends an engine lathe, which has higher process capability resulting in a process standard deviation of 0.002 inch.
- However, the processing cost increases to \$9.00 per unit from the previous \$7.00. Other data are the same as before.
- The unit cost of output, number of units of scrap generated, and number of raw units required to produce 1000 finished units are determined as follows:
- Because the engine lathe is the second manufacturing technological alternative, $J = 2$.

Numerical Example

- $K = 1$, because there is no change in the design specifications. $Z^u_{21} = 1.5$, $Z^l_{21} = -1.5$, percent rejection above the upper limit = 6.7, percent rejection below the lower limit = 6.7, total percent rejection = 13.4, $k^s_{21} = 0.1547$, $k^i_{21} = 1.1547$
- Hence,
 - i. Number of units scraped, $Y^s_{21} = k^s_{21} Y^o_{21} = 0.1547 \times 1000 = 154.7 = 155$
 - ii. Number of raw units (input) required, $Y^i_{21} = k^i_{21} Y^o_{21} = 1.1547 \times 1000 = 1155$
 - iii. Unit output cost, $X^o_{21} = k^i_{21} X^i_{21} - k^s_{21} X^s_{21} + k^i_{21} f(Y^i_{21}) = 1.1547 \times 10.00 - 0.1547 \times 2.00 + 1.1547 \times 9.00 = 21.63$

Understanding benefits of concurrent engineering

The Basic Data Used in the Shaft Examples

Manufacturing options	Unit Processing Costs	Setup time	Unit Processing time	Process standard Deviation
Turret lathe	7.00	20.00	1.00	0.003
Engine lathe	9.00	25.00	0.80	0.002
ASM	12.00	50.00	0.70	0.001

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Product Development Process and Automation

- ✓ **Characterization of Concurrent Engineering Framework**
- ✓ **Difficulties in CE implementation**

Product Design and Manufacturing Systems

- Concurrent engineering considers all the issues involved in product development, from conception to disposal (life cycle), in a concurrent and integrated manner.
- Techniques and systems that support CE by advising designers on aspects that reduce life-cycle problems include the use of:
 - i. Design teams
 - ii. Handbooks
 - iii. Checklists and procedures
 - iv. Process planning and manufacturing simulation
 - v. Rule based expert systems.

How to design a concurrent engineering program: a framework

It consists of three phases:

Phase I : Identification of Influencing Dimensions and their Levels

- i. Identify the dimensions of the products and the programs that influence the concurrent engineering approach, such as product complexity, product technology, competition, and resource tightness.
- ii. Establish the levels of influencing dimensions on an individual basis using information on the product features, product requirements, and any other aspects.

How to design a concurrent engineering program: a framework

- iii. For example, levels of product complexity could be catalog items, mostly common parts (little state-of-the-art), state-of-the-art items (sensitive interfaces), and pushing the state-of-the-art envelope. These levels can be categorized as A, B, C, and D representing increasing order of complexity.
- iv. Establish an aggregate level by considering the relative importance of the influencing dimensions. This establishes the “should be” concurrent engineering environment for the product development program.

How to design a concurrent engineering program: a framework

Phase II : Identification of Concurrent Engineering Elements and Their Levels:

Identify the concurrent engineering elements and sub-elements as well as their levels to support the “should be” concurrent engineering environment.

Phase III : Evaluation:

Determine the improvements that are needed to match the required levels of concurrent engineering elements starting from your present stage. These improvements will depend on the influencing dimensions of products and programs, as well as CE elements and their levels.

Concurrent engineering environment influencing dimensions

The dimensions of the products and programs that influence the concurrent engineering environment.

1. Product complexity
2. Product technology
3. Program structure
4. Program futures
5. Competition
6. Business relationships
7. Team scope
8. Resource tightness
9. Schedule tightness

Major elements of the concurrent engineering environment

Four major elements of the concurrent engineering environment:

- i. Organization
- ii. Requirements
- iii. Communications
- iv. Product Development Methodology

These elements and their sub elements provide a basis for assessing specific capabilities within individual programs to address the concurrent engineering approach to product and process development.

Program and Product Influencing Dimensions

	Levels of Concurrent Engineering Influencing Dimensions			
	A	B	C	D
Product complexity	Catalog items	Mostly common parts, little state of art	State-of-the-art items Sensitive interfaces	Pushing the state-of-the-art envelope
Product technology	Available technology	New applications/ custom built	New capabilities from core technologies	New core technology
Program structure	Small staff/informal communications	Moderate size staff, layered structure	Multiple locations, formal communications	Large staff, deep reporting structure
Program futures	No follow-on planned	Investments made to minimize costs	Investment plan contractual boundaries	Significant future opportunities
Competition	Minimal competition	Significant barriers to market entry exist	Competitive analysis, market expansion	Active competition, pressure to anticipate and react

	Levels of Concurrent Engineering Influencing Dimensions			
	A	B	C	D
Business relationships	Arms length	Contractual	Teaming	Enterprise-wide, common goals
Team scope	Dominant perspective	Competing dominant perspective	Competing perspective Interrelated optimization	Aggressive optimization to meet requirements
Resource tightness	Not severely constrained	Limited in-process resolution	No in-process correction	Tightly constrained
Schedule tightness	Significant schedule slack time	Adequate for first success	Aggregative, requires first-pass success	Severely constrained

Difficulties in CE Implementation

Concurrent engineering is most desirable from the point of view of reducing cost, improving quality, and decreasing development time. These are, however, sources of difficulty in implementing CE. They include:

- i. Characteristics of the design process
- ii. Volume and variety of the life cycle knowledge
- iii. Supervision of life-cycle functions

Difficulties in CE Implementation

i. Characteristics of Design Process

- The characteristics of design process are one of the sources of difficulty in achieving integrated concurrent engineering.
- The design process involves a number of activities separated into stages, such as conceptual design, detailed design, analysis, and evaluation.
- Each stage is further divided into subproblems.
- Each subproblems is then solved iteratively to evolve an acceptable design.

Difficulties in CE Implementation

- It is the separation of the design problem into stages and of each stage into subproblems that causes problems.
- The organization can result in suboptimization as the designed concentrates on narrow issues and ignores small concurrent engineering problem.

Difficulties in CE Implementation

ii. Volume and Variety of Life-Cycle Knowledge

- The knowledge required to consider a number of life-cycle factors such as design, manufacturing, manufacturing control, testing, servicing, and redesign is voluminous.
- Furthermore, a large variety of knowledge including both qualitative and quantitative knowledge is required for all these functions.

Difficulties in CE Implementation

- The variety and volume of knowledge may force the designers to concentrate on the optimization of single life-cycle factors rather than taking a holistic approach.
- Therefore, the volume and variety of knowledge are another source of difficulty in achieving integrated CE.

Difficulties in CE Implementation

iii. Separation of Life-Cycle Functions

- Life-cycle functions such as design, process planning, manufacturing, testing, maintenance, and service are often separated.
- Different departments are responsible for different functions.
- Therefore, there is a problem of communicating knowledge of all the life-cycle factors to the design department as and when needed.
- Separation of life-cycle functions is the third source of difficulty in achieving integrated concurrent engineering.

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Product Development Process and Automation

- ✓ Concurrent Engineering Techniques
- ✓ Examples of a CE Technique (QFD)

Concurrent Engineering Techniques

A number of techniques are useful for implementing Concurrent engineering. They are as follows:

- Quality function deployment
- Failure-mode and effect analysis
- Axiomatic design
- Design for manufacturing guidelines
- Design science
- Design for assembly

Concurrent Engineering Techniques

A number of techniques are useful for implementing Concurrent engineering. They are as follows:

- Robust design
- Manufacturing process design rules
- Computer-aided design for manufacture
- Value engineering
- Group technology

Quality function deployment is cross sectional planning tool.

Quality Function Deployment

- A major problem with the traditional product development process is that customers and engineers speak different languages
- A customer might express a desire to own a car that is easy to start. The translation of this requirement into technical language might be “car will start within 10 seconds of continuous cranking.” Or, a requirement that “soap leaves my skin feeling soft” demands translation into pH or hardness specifications for the bar of soap.
- The actual intended message can be lost in the translation and subsequent interpretation by design or production personnel.

Quality Function Deployment

- The Japanese developed an approach called **quality function deployment (QFD)** to meet customers' requirements throughout the design process and also in the design of production systems.
- QFD is a planning process to guide the design, manufacturing, and marketing of goods by integrating the voice of the customer throughout the organization.
- Through QFD, every design, manufacturing, and control decision is made to meet the expressed needs of customers. It uses a type of matrix diagram to present data information

Quality Function Deployment

- QFD is used successfully by manufacturers of electronics, appliances, clothing, and construction equipment, by firms such as General Motors, Ford, Mazda, Motorola, Xerox, Kodak, IBM, Procter and Gamble, Hewlett-Packard, and AT&T.
- At the strategic level, QFD presents a challenge and the opportunity for top management to break out of its traditional narrow focus on results, which can only be measured after the fact, and to view the broader process of how results are obtained.

Quality Function Deployment

- Under QFD, all operations of a company are driven by the voice of the customer, rather than by edicts of top management or the opinions or desires of design engineers.
- If customer needs can be identified properly in the first place, then wasteful effort is eliminated, which is the principal focus of QFD.
- Use of QFD focuses on the drivers of customer satisfaction and dissatisfaction, making it a useful tool for competitive analysis of product quality by top management.
- Perhaps most significant, though, QFD reduces the time for new product development.

The House of Quality

- A set of matrices is used to relate the voice of customer to a product's technical requirements, component requirements, process control plans, and manufacturing operations.
- The first matrix, the customer requirement planning matrix shown in Figure.1, provides the basis for the QFD concept.
- Building the house of quality consists of six basic steps:
 1. Identify customer requirements
 2. Identify technical requirements
 3. Relate the customer requirements to the technical requirements

The House of Quality

4. Conduct an evaluation of competing products or services
 5. Evaluate technical requirements and develop targets
 6. Determine which technical requirements to deploy in the remainder of the production/delivery process.
- To illustrate the development of the House of Quality and the QFD process, the task of designing a new fitness center in a community with two other competing organizations is presented.

The House of Quality

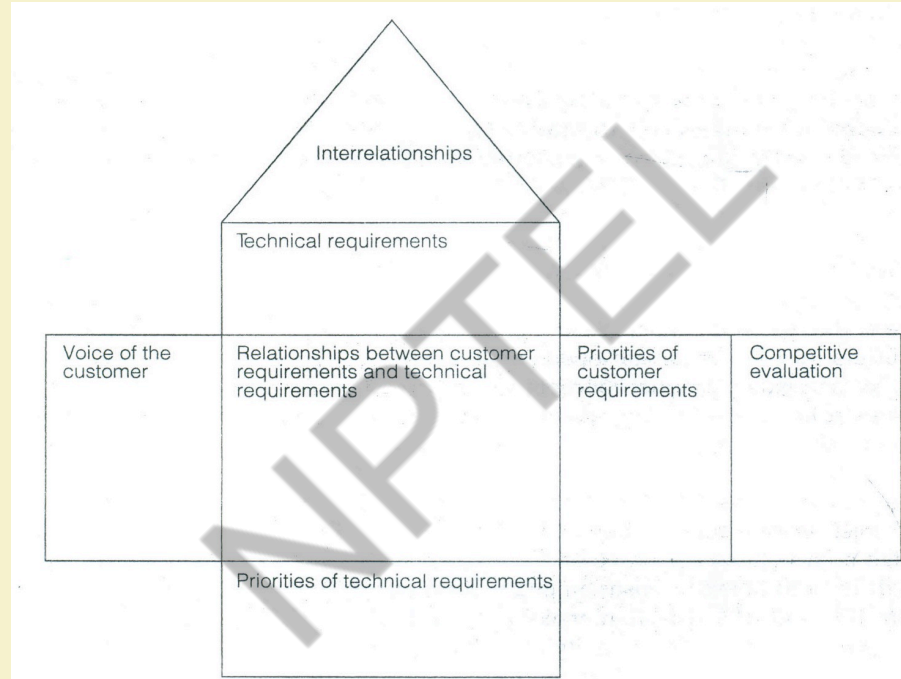


Figure 1. The House of Quality

Step 1: Identify Customer Requirements

- The voice of the customer is the primary input to the QFD process.
- Many methods can be used to gather valid customer information. The most critical and the most difficult step of the process is to capture the essence of the customer's needs and expectations.
- Figure 2 shows the voice of the customer in the House of Quality for the fitness center, perhaps based on a telephone survey or focus groups.

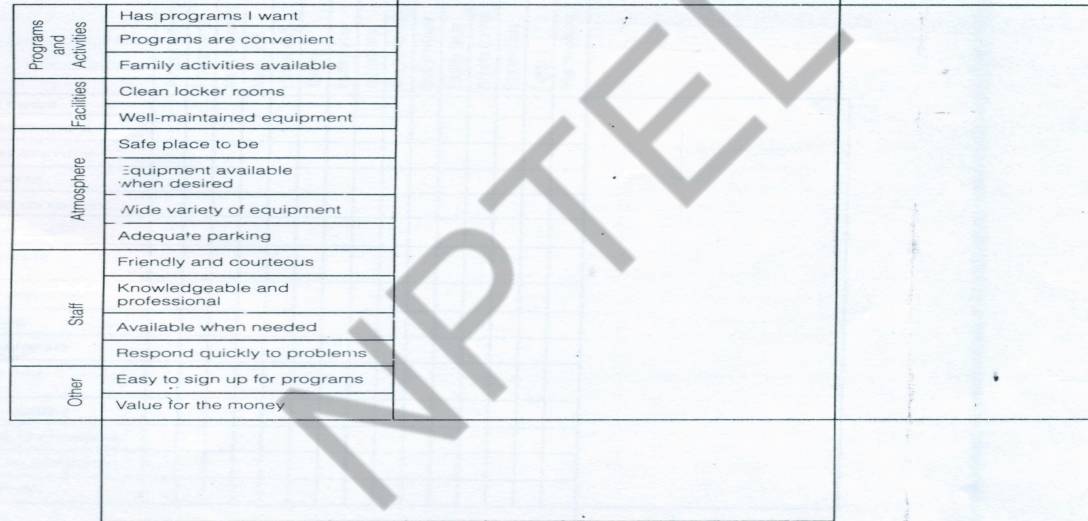


Figure 2. Voice of the Customer in the House of Quality

Step 2: List the technical requirements that provide the foundation for the product or service design

- Technical requirements are design characteristics that describe the customer requirements as expressed in the language of the designer or engineer.
- Essentially, they are the “hows” by which the company will respond to the “whats” – customer requirements.
- They must be measurable, because the output is controllable and compared to the objective targets.

Step 2: List the technical requirements that provide the foundation for the product or service design

- For the fitness center, these requirements include the number and type of program offerings and equipment, times, staffing requirements, facility characteristics and maintenance, fee structure, and so on.
- Figure 3 adds this information to the House of Quality.
- The roof of the House of Quality shows the interrelationships between any pair of technical requirements

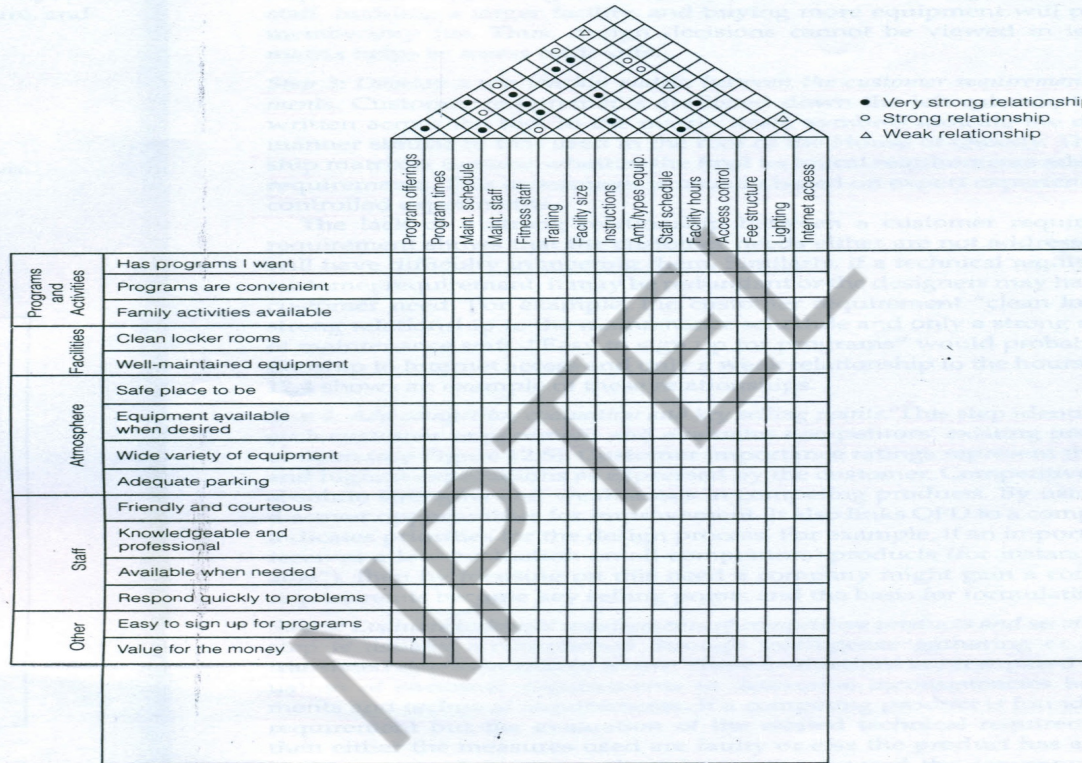


Figure 3. Technical Requirements in the House of Quality

Step 3: Develop a relationship matrix between the customer requirements and the technical requirements

- In the matrix itself, symbols indicate the degree of relationship in a manner similar to that used in the roof of the House of Quality.
- The purpose of the relationship matrix is to show whether the final technical requirements adequately address customer requirements.
- This assessment is usually based on expert experience, customer responses, or controlled experiments.
- Figure 4 shows an example of relationship matrix.

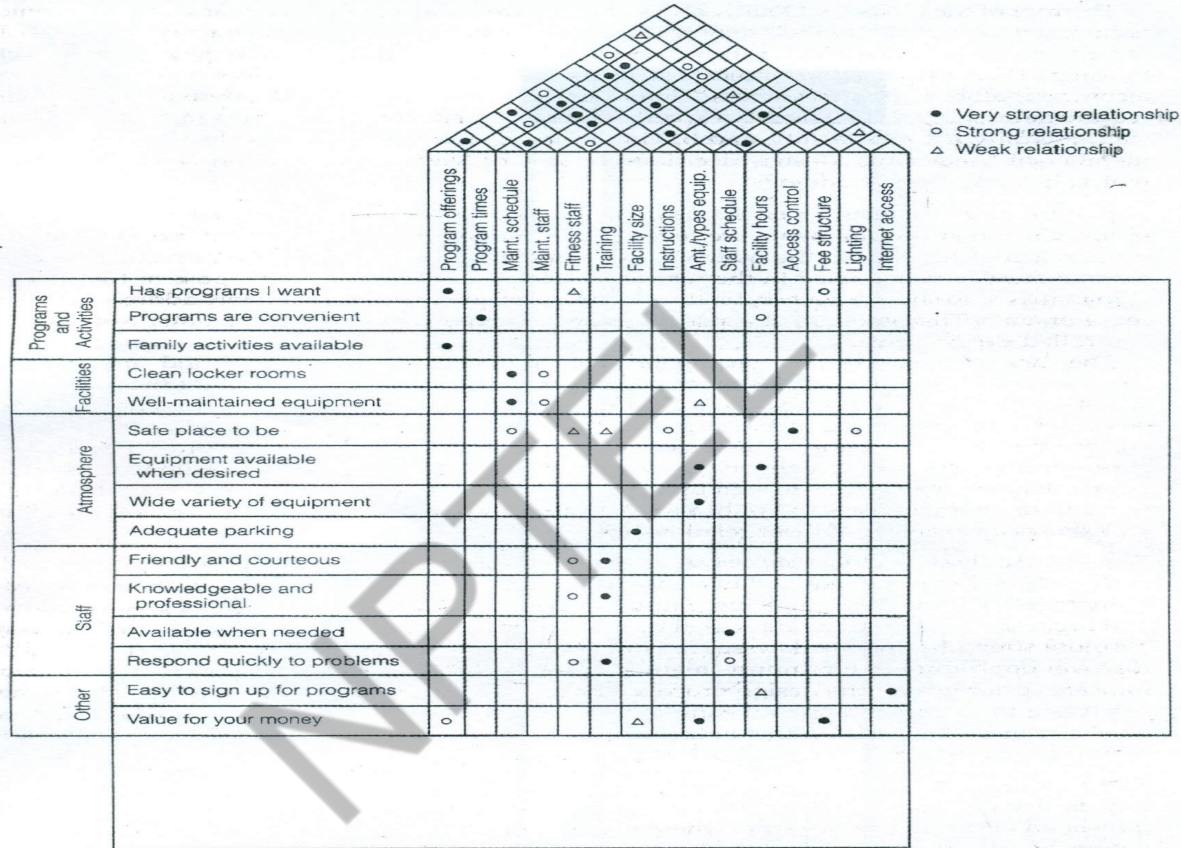


Figure 4: Relationship Matrix

Step 4: Add competitor evaluation and key selling points

- This step identifies important ratings for each customer requirement and evaluates competitors' existing products or services for each of them (see Figure 5).
- Customer importance ratings represent the areas of greatest interest and highest expectations as expressed by the customer.

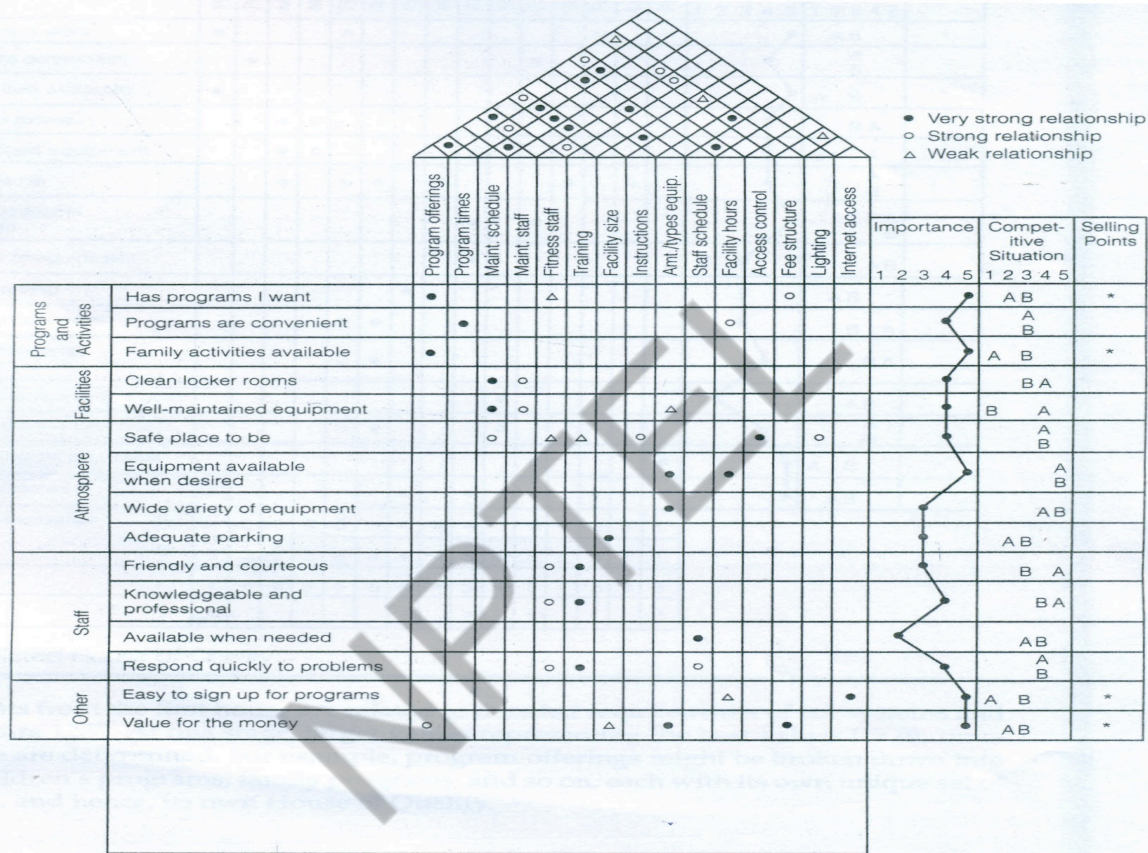


Figure 5. Competitive evaluation

Step 5: Evaluate technical requirements of competitive products and services and develop targets

- This step is usually accomplished through intelligence gathering or product testing and then translated into measurable terms.
- These evaluations are compared with the competitive evaluation of customer requirements to determine inconsistencies between customer requirements and technical requirements.

Step 5: Evaluate technical requirements of competitive products and services and develop targets

- On the basis of customer importance ratings and existing product strengths and weaknesses, targets for each technical requirements are set, as shown in Figure 6.
- Setting a higher target for these requirements will help to meet this critical need and be a source of competitive advantage.

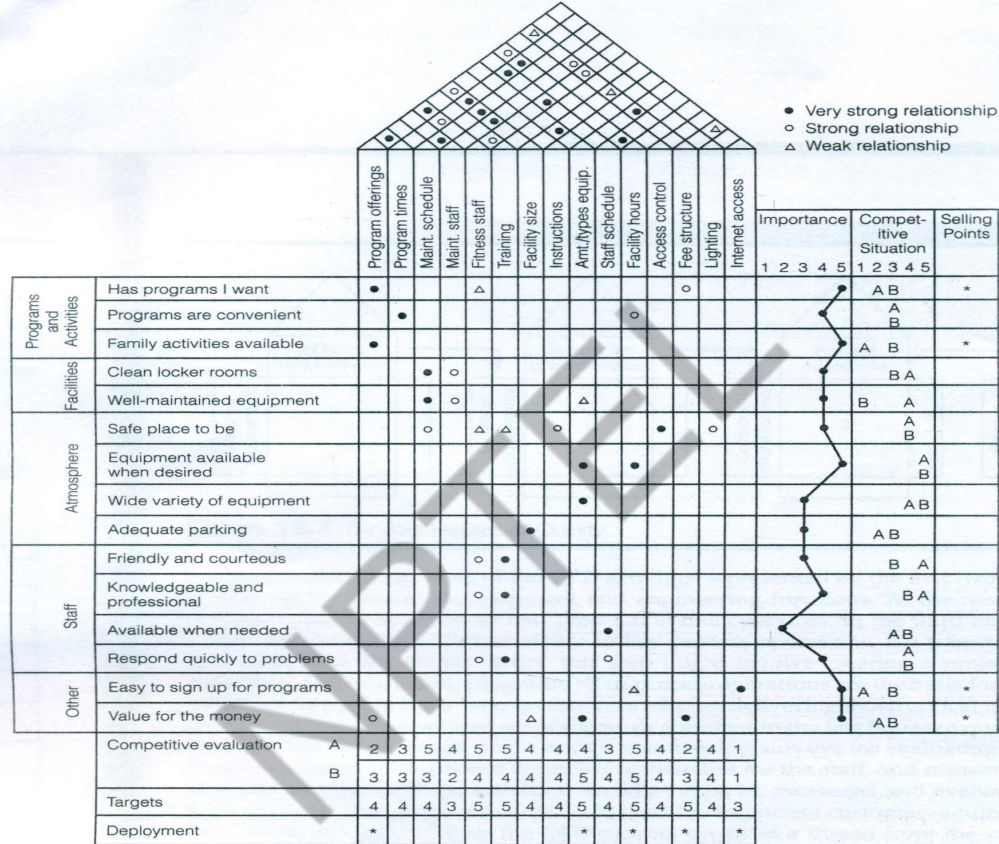


Figure 6. Completed house of Quality

Step 6: Select technical requirements to be deployed in the remainder of the process

- The technical requirements that have a strong relationship to customer needs, have poor competitive performance, or are strong selling points are identified during this step.
- These characteristics have the highest priority and need to be “deployed” throughout the remainder of the design and production process to maintain a responsiveness to the voice of the customer.
- Those characteristics not identified as critical do not need such rigorous attention.

The QFD Process

- The house of Quality provides the marketing function with an important tool to understand customer needs and gives top management strategic direction.
- The voice of the customer must be carried throughout the production/delivery process.
- Three other “houses of quality” are used to deploy the voice of customer to (in a manufacturing setting) component parts characteristics, process plans, and quality control.

The QFD Process

- The second house is similar to the first house but applies to subsystems and components the technical requirements from the first house are related to detailed requirements of subsystems and components (Figure 7).
- At this stage, target values representing the best values for fit, function and appearance are determined.
- In manufacturing, most of the QFD activities represented by the first two houses of quality are performed by product development and engineering functions. At the next stage, the planning activities involve supervisors and production line operators.

The QFD Process

- In the third house, the process plan relates the component characteristics to key process operations, the transition from planning to execution.
- Key process operations are the basis for a control point. A control point forms the basis for a quality control plan delivering those critical characteristics that are crucial to achieving customer satisfaction, as specified in the last house of quality.
- Thus, the QFD process provides a thread from the voice of the customer, through design and production/delivery activities, to daily management and control.

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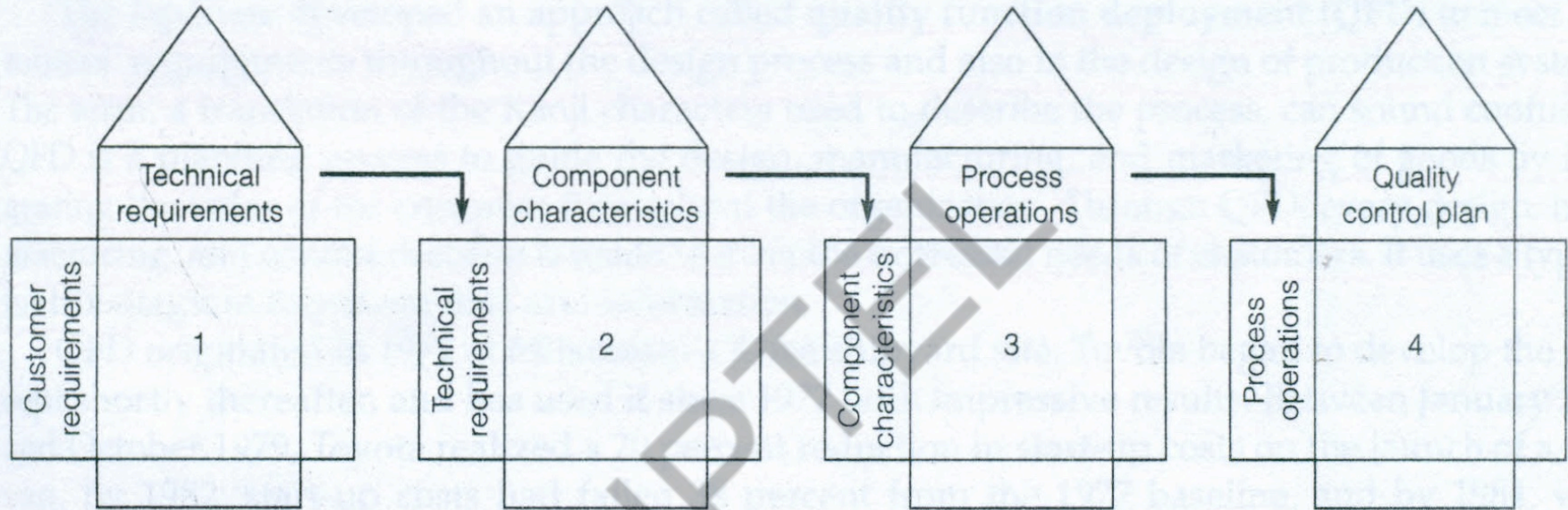


Figure 7. The Four Houses of Quality

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Thank You!!

