| PRODUCT LIFE CYCLE MANAGEMENT<br>**B.E, VI Semester, Mechanical Engineering**<br>**[As per Choice Based Credit System (CBCS) scheme]** | | | |
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| **Course Code** | 15ME835 | **CIE Mark** | 40 |
| **Number of Lecture Hours/Week** | 03 | **SEE Marks** | 60 |
| **Total Number of Lecture Hours** | 40 | **Exam Hours** | 03 |
| **Credits – 03** | | | |

**Course Objectives:**

- Familiarize with various strategies of PLM
- Understand the concept of product design and simulation
- Develop new product development, Product structure and supporting systems
- Interpret technology forecasting and product innovation and development in business process
- Understand product building and product configuration

**Course outcomes:**

- Describe the concepts of product of life cycle management and its applications in product development process.
- Apply the models of Product Life Cycle for product development process and select the appropriate product life cycle management tools and systems to enhance the collaborative product development.
- Analyse the strategies of Product life Cycle Management and emphasize the significance of digital manufacturing and product building structures.



**MODULE –I**

**INTRODUCTION TO PLM AND PDM**
Introduction to PLM, Need for PLM, opportunities and benefits of PLM, different views of PLM, components of PLM, phases of PLM, PLM feasibility study. PLM Strategies, strategy elements, its identification, selection and implementation. Product Data Management, implementation of PDM systems.

### 1.1 Product Lifecycle Management (PLM)

Product lifecycle management makes it possible to command the whole lifespan of a product and the information connected with it. Efficient product lifecycle management enables companies to compete successfully in international and global markets.

### 1.1.1 What is a product?
### 1.1.2

Usually, when talking about products we mean tangible products i.e. goods. The term goods refers to physical, tangible products that can be owned, traded, and distributed to different places at different times without changing their identity. However, a product in a modern world can also be something very intangible such as a piece of software, a piece of knowledge or an algorithm or a formula. They are products as much as tangible products are.

When referring to a product in this book, we refer to three different kinds of products:

1. Goods meaning physical, tangible products
2. Services
3. Intangible products meaning non-physical products that are not services.

For example:

■ Software

■ An algorithm

## 1.2 PLM: What is it?

In many ways, product data management can be seen as a subset of PLM. First EDM (Engineering Data emerged in Management) and then PDM (Product Data Management) the late 1980s as engineers in the manufacturing industries recognized a need to keep track of the growing volumes of design files generated by CAD (Computer Aided Design) systems. PDM allowed them to standardize items, to store and control document files, to maintain BOM's, to control item, BOM and document revision levels, and immediately to see relationships between parts and assemblies. This functionality let them quickly access standard items, BOM structures, and files for reuse and derivation, while reducing the risk of using incorrect design versions and increasing the reuse of existing product information.

However, the benefits of operational PLM go far beyond incremental savings, yielding greater bottom line savings and top-line revenue growth not only by implementing tools and technologies, but also by making necessary, and often tough, changes in processes, practices and methods and gaining control over product lifecycles and lifecycle processes. The return on investment for PLM is based on a broader corporate business value, specifically the greater market share and increased profitability achieved by streamlining the business processes that help deliver innovative, winning products with high brand image quickly to market, while being able to make informed lifecycle decisions over the complete product portfolio during the lifecycle of each individual product. The scope of product information being stored, refined, searched, and shared with PLM has expanded. PLM is a holistic business concept developed to manage a product and its lifecycle including not only items, documents, and BOM's, but also analysis results, test specifications, environmental component information, quality standards, engineering requirements, change orders, manufacturing procedures, product performance information, component suppliers, and so forth.

On the other hand, modern PLM system capabilities include workflow, program management, and project control features that standardize, automate, and speed up product management operations.

Web-based systems enable companies easily to connect their globally dispersed facilities with each other and with outside organizations such as suppliers, partners, and even customers.

A PLM system is a collaborative backbone allowing people throughout extended enterprises to work together more effectively.

Operational efficiencies are improved with PLM because groups all across the value chain can work faster through advanced information retrieval, electronic information sharing, data reuse, and numerous automated capabilities, with greater information traceability and data security. This allows companies to process engineering change orders and respond to product support calls more quickly and with less labor. They can also work more effectively with suppliers in handling bids and quotes, exchange critical product information more smoothly with manufacturing facilities, and allow service technicians and spare part sales reps to quickly access required engineering data in the field.

In this way, PLM can result in impressive cost savings, with many companies reporting pay-off periods of one to two years or less based solely on reduced product development costs. PLM also enables better control over the product lifecycle. This gives opportunities for companies to boost revenue streams by accelerating the pace at which innovative products are brought to market. Excellent lifecycle control over products also gives new opportunities to control product margins more carefully and remove poorly performing products from the markets. This set of benefits, driving top line revenue growth and bottom line profitability, makes ROI extremely compelling, with some industry analysts characterizing PLM as a competitive necessity for manufacturing and software businesses and today also for service businesses.

Product Lifecycle Management (PLM) is the business activity of managing, in the most effective way, a company's products all the way across their lifecycles; from the very first idea for a product all the way through until it's retired and disposed of PLM manages both individual products and the Product Portfolio, the collection of all of a company's products. PLM manages products from the beginning of their life, including development, through growth and maturity, to the end of life. The objective of PLM is to increase product revenues, reduce product-related costs, maximise the value of the product portfolio, and maximise the value of current and future products for both customers and shareholders.

## 1.3 Need for PLM

**PLM** can be used to increase output with constant resources, to increase revenues or to reduce the resources used to produce a constant output.

### 1.3.1 PLM helps organisation to achieve this through:

- Efficiency improvements.

- Improving development for new products.
- Reduced costs.
- Increase productivity.
- Improved quality of products.

## 1.4 Product Lifecycle Management (PLM)

Product lifecycle management, or PLM, does not refer to any individual computer software or method. It is a wide functional totality; a concept and set of systematic methods that attempts to control the product information previously described. The idea is to control and steer the process of creating, handling, distributing, and recording product related information. According to the definition by Kenneth McIntosh some years ago:

Engineering data management – EDM (currently the appropriate acronym would be PLM) is a systematic way to design, manage, direct, and control all the information needed to document the product through its entire lifespan: development, planning, design, production, and use.

In daily business, the problems of product lifecycle management typically become evident in three different areas:

1. The concepts, terms and acronyms within the area of product lifecycle management are not clear and not defined within companies. This means that the information content connected to certain terms is not clear and the concepts how to utilize to the product related information are even fuzzier (for example the definition: what is product lifecycle and what are its phases).

2. The use of the information and the formats in which it is saved and recorded vary. Information has usually been produced for different purposes or in some other connection but it should still be possible to utilize it in contexts other than the task for which it was produced: in a different locality or even in a separate company. An example might be the use in e-business sales, of a product structure originally created during the design phase. The lack of an integrated information processing system often means that the product structure must again be manually fed into the e-business sales system.

3. The completeness and consistency of information produced in different units, departments or companies cannot be guaranteed. This problem arises when the product data is produced and stored on different data media or even as paper documents, and when the parties concerned have different approaches to the protection and handling of information. One practical problem can be clarifying the location of the latest version of a certain document.

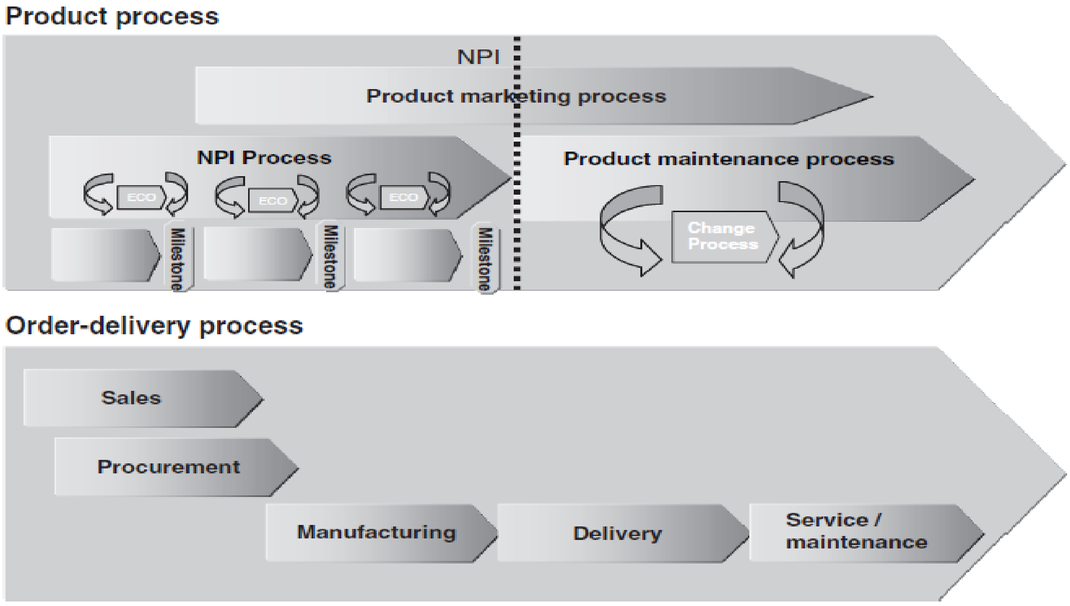


**Figure 1.** Product (product development, productizing, product design maintenance and marketing) process; order and delivery (customer) process. (Note: In many fields of manufacturing industry, the order-delivery process is also called the customer process due to the frequency of build-to-order production. The fulfillment of the customer's purchase order, i.e. the manufacture and delivery of the actual product, is already allocated to a certain customer and to a certain order.) NPI refers to New Product Introduction.

## 1.5 Product lifecycle management concept



The product lifecycle management concept, at its simplest, is a general plan for practical product lifecycle management in daily business at the corporate level, in a particular business or product area. It is a compilation of business rules, methods, processes, and guidelines as well as instructions on how to apply the rules in practice. Usually, the product lifecycle management concept covers at least the following areas:

1. Terms and abbreviations used in this field (definition of product, lifecycle, lifecycle phases, etc.)
2. Product information models and product models
3. Definition of products and product-related information objects (items, structures, product-related documents, definition of product information, etc.)
4. Product lifecycle management practices and principles used and applied in the company (how products are managed throughout their lifecycle, identification of information management principles such as versioning principles, information statuses, etc.)
5. Product management related processes

(a) Product information management processes

6. Instructions on how to apply the concept in everyday business

The significance of building this kind of product information concept lies in the need to set common business rules for the entire corporation and its business and product areas. A carefully specified concept makes it possible to achieve synergies between businesses and between products. Common product information concept allows for the smooth and speedy implementation of PLM-related processes and practices because the most crucial areas of information have been agreed at common and conceptual levels.

A good PLM-concept is never static; it keeps evolving in tune with the business and its requirements.

**1.6 Essential elements of PLM**

PLM can be thought of as both (a) a repository for all information that affects a product, and (b) a communication process between product stakeholders: principally marketing, engineering, manufacturing and field service. The PLM system is the first place where all product information from marketing and design comes together, and where it leaves in a form suitable for production and support.

A few analysts use "PLM" as an umbrella term that includes engineering CAD (for "information authoring"). But product-related authoring tools can include word processors; spreadsheet and graphics programs; and even requirements analysis and market assessment tools. PLM systems, on the other hand, are necessarily broad to encompass the entire reach of a product lifecycle, and therefore are primarily focused on data management, rather than data authoring.

The essential elements of PLM are:

- Management of design and process documents
- Product structure (bill of material) management
- Central data vault (electronic file repository)
- Part and document classification and metadata ("attribute") management
- Materials content identification for environmental compliance
- Product-focused project task assignment
- Workflow and process management for approving changes
- Multi-user secured access, including "electronic signature"
- Data export for loading downstream ERP systems

**1.7 Product lifecycle management systems**

A product lifecycle management or PLM system – what is usually meant by the term PLM – is ideally an information processing system or set of IT-systems that integrates the functions of the whole company. This integration is done through connecting, integrating and controlling the company's business processes and produced products by means of product data. At the practical level, the adoption of PLM is still too often restricted to only certain areas of certain business processes, such as product design and development. Kenneth McIntosh has proposed that PLM can be the operational frame of CIM (*Computer Integrated Manufacturing*) – one of the isms of industrial business. In other words, it is a system or set of systems, which integrate the functions of the whole company with the help of information technology. PLM is above all a connecting technology, not an individual technology islet or information processing system like a CAD (*Computer Aided Design*) system. A specialized IT-system can be very efficient in its own area but such systems usually cause bottlenecks elsewhere in the company's dataflows and at the level of practical implementation in corporate IT-systems. The most important business processes, the product process and the order-delivery process, in manufacturing industry are cross-functional and cross-organizational. The task of PLM, in one sense, is to provide the necessary conditions for

Connecting separate information data systems, processes and automation islets.

Additionally, PLM should command a wide variety of information systems and thus give birth to integrated totalities. Commanding the totality of various processes brings considerable value to companies by seamlessly integrating information from organization-wide processes using different information processing systems.

Figure 2 illustrates the core processes of an industrial enterprise. It shows how the core processes are cross functional and cross organizational.

Figure 3 illustrates how a PLM system is positioned as a common and central databank within the field of operation of the process oriented manufacturing enterprise described in figure 2.

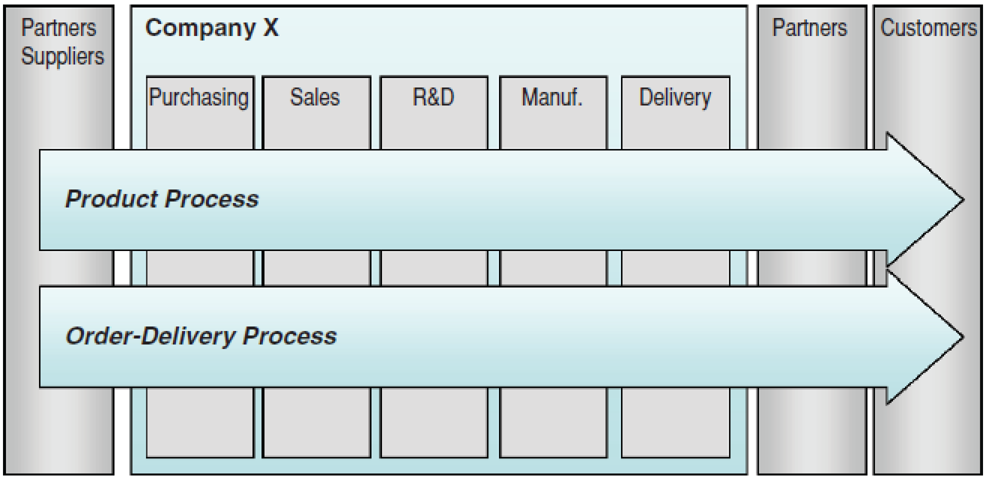


**Figure 2.** The core processes and functional verticals of an industrial enterprise.

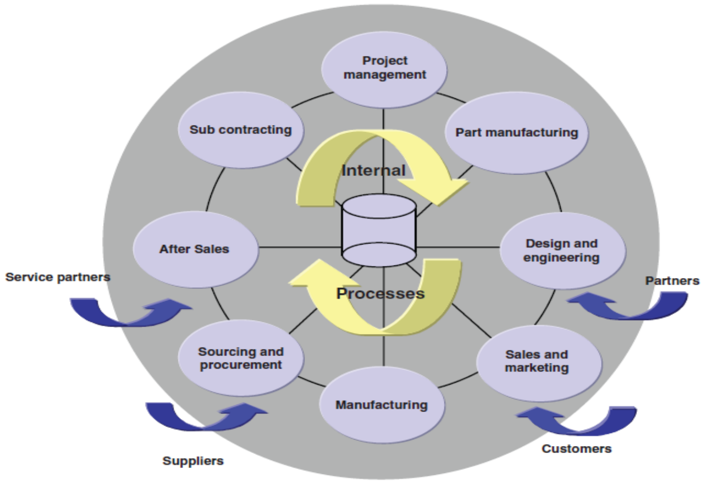


**Figure 3.** The PLM system often creates a wide totality of functions and properties with which to support the different processes involved in the creation, recording, updating, distribution, utilization, and retrieval of information.

## 1.8 Strategy Elements

The name given to a strategy has to be meaningful and self-descriptive. For example "control of the seas". At a lower level than the strategy itself are "strategy elements", addressing particular resources and activities, which also
need to have simple names and clear descriptions.

"Customer focus" is an example of a strategy element that could be identified in the second step of PLM strategy development. Then it would have to be described in the context of the organisation, activities and resources of the lifecycle. It would soon be realised that "customer focus" isn't sufficiently descriptive or wide-ranging to build a strategy for the product lifecycle. For example, it says nothing about products or human resources. "Customer focus" is more a PLM principle than a strategy. It's generally agreed to be "a good thing". Usually a strategy can't be based on just one strategy element, one improvement initiative, or one resource. It's not enough to claim "Lean" as the PLM
Strategy, or to claim that the choice of a particular location for the PLM organisation is the strategy. PLM Strategies aren't one-dimensional. Several strategy elements need to be combined to develop a particular organisation's strategy.

It may appear that all elements should be needed, but in practice, organisations have limited resources so can't do everything. An attempt to do everything would lead to confusion, and probably nothing would get done. As a result, choices have to be made and a clear strategy has to be created.

The exact meaning of a strategy element will differ from one company to another. For example, the strategy elements of ''fastest time-to-market'' and ''lowest-cost competitor'' could both be implemented in many ways. ''Fastest time-to-market'' could be implemented by building up a pre-defined stock of solutions, by increasing the number of engineers, or by shortening the product development process by removing non-value-adding activities. ''Lowest-cost competitor'' could be implemented with cost reduction programs, capital expenditure cuts, headcount reductions, or by improving the effectiveness of the product development process. The criteria for selecting strategy elements, and deciding how they'll be implemented, will be made clear to some extent by the objectives provided by the business strategy, and to some extent by the application of PLM principles.

The strategy development activity aims to find the most suitable way to carry out the activities of the product lifecycle and meet the objectives with the limited resources available. It may well be that there's no strategy that allows the PLM activity to meet the objectives with the resources available. In this case, either the objectives, or the resources, need to be changed. It is, of course, much better to find this out during strategy development than by failing to meet the objectives.

Business managers shouldn't ask PLM to aim for the highest functionality product, the fastest time to market and the lowest costs. In practice, this is likely to be impossible. Just as in war, commanders who don't have very clear objectives and feasible strategies won't succeed. By describing, and then analysing, strategies this can be found out before the battle.

**1.9 PLM Benefits**

PLM software delivers key benefits, which we'll explore below.

- Reduce Risk. In a world of regulations, each industry has to comply with specific regulatory standards. ...
- Increased Productivity. ...
- Cost Management. ...
- Accelerated Time to Market. ...
- Increased Revenue. ...
- Data Sharing. ...
- Centralization. ...
- Better Quality Product.

## 1.10 Data Management

A Product Data Management (PDM) application will provide people in the product lifecycle with exactly the right information at exactly the right time. Having digital product data under PDM control will help achieve the objectives of improved product development and support. With PDM, it will be much quicker and easier to access, retrieve and reuse product data. The PDM application will manage all data defining and related to the product across the product lifecycle from initial idea to retirement. It will provide controlled access to correct versions and configurations.

It will enable tracking of product configurations.

### 1.10.1 Legacy Data

The different types of legacy data will be identified. Policies will be defined for managing them and, where possible, for eliminating them.

### 1.10.2 Data Exchange

A review will be made of the need for different data formats. Where these are found to be necessary, standard approaches will be implemented for data exchange.

## 1.11 Product data or product information

Product data refers in this context to information broadly related to the product.

Product data can be roughly divided into three groups:

1. Definition data of the product
2. Life cycle data of the product
3. Metadata that describes the product and lifecycle data

**The definition data of the product** – determines physical and/or functional properties of the product – i.e. form, fit and function of the product – describes the properties of the product from the viewpoint of a certain party (e.g. customer or producer) and connects the information to the interpretation of the party in question. This group includes very exact technical data as well as abstract and conceptual information about the product and related information. This group of information also includes the images and conceptual illustrations that characterize the product. So more or less this set of information could be characterized being a complete product definition. The wide spectrum of information and the difference in the contents of definition data can easily cause problems, owing to different interpretations and contexts.

**The life cycle data of the product** – is always connected to the product and the stage of the product or order-delivery process. This group of information is connected to technological research, design and to the production, use, maintenance, recycling, and destruction of the product, and possibly to the official regulations connected with the product.

### 1.12 Differences between PLM and PDM

- PLM manages product information within a database
- PLM specifies and controls the complete, approved engineering design: requirements, specifications, procedures, configurations. It defines the current product structures and planned changes, as well as maintains the history of all previous design decisions.
- PLM data is usually created and managed by engineering in cooperation with other product managers in purchasing, production, quality, service and sales. It's the container for how to buy, fabricate, assemble, test, calibrate, inspect, install, repair and even sell the end product. PLM is a cross-department information storehouse, and its data is often exported to manufacturing systems and supply chain partners.
- PLM manages objects – parts, documents, change forms, and supporting data – within a database. These objects have:

- Descriptive attributes like owning organization, identifying number, name/title, revision (technical content) and lifecycle (business rules for what can be done with that content), weight and unit of measure. CAD files (and any other files) can be attached to database records to further describe the object.
- Relationships to other objects: parts have requirements, specifications, inspection procedures, etc.; assemblies have components with quantities; purchased parts have approved sources; designed parts have design drawings.

These attributes and relationships are created, reviewed and approved using system rules and change workflows.

### 1.13 PDM MANAGES CAD FILES WITHIN A COMPUTER FILE SYSTEM

CAD drawings are files, and reside principally in a computer's file system or on a network share. A CAD file often represents a single part, but several files may represent one part or one file can represent multiple parts.

Product data management ("PDM") is a specialized file system manager, somewhat like a CAD-oriented Windows Explorer. PDM's primary job is to manage mechanical CAD files, and the linkages between related files. These related files (the "model") are usually in a proprietary format defined by the CAD vendor.

PDM assists in organizing the mechanical aspects of a product, but it's the CAD model (or its derivative drawings), and not PDM itself, that has utility to downstream users.

**1.1.4 COMPONENTS OF PLM**

Increasing numbers of manufacturers are utilising PLM solutions, to optimise all aspects of their product development processes. Nevertheless, it can be hard to offer a precise definition of PLM. Yet, to know exactly how PLM can benefit business, it is essential to know what PLM solutions have to offer. Regardless of how PLM is defined, there are the ‘must have’ components, which are vital for any PLM solution to be effective. We’ve put together an overview of the 7 essential components of PLM solutions.

**#1 Document Management**

This is vital for being able to store, track and manage all the data associated with your product development processes. It includes everything from graphics and text right through to engineering calculations. Comprehensive document management makes it easier to track any data changes and monitor access to documents by creating a single, central data store.

**#2 Embedded Visualisation**

Embedded visualisation allows for collaboration, between mechanical and electrical areas, using centralised digital product information. It also makes it possible to view any product data, without needing authentication from the native tool.



**#3 Workflow**

This component of a PLM solution makes it possible to define product development processes fully, through a standardised method. It also ensures that all process and procedures are adhered to and all necessary related tasks taken.

**#4 Distributed Collaboration**

Companies increasingly operate across multiple locations, with internal and external partners. Distributed collaboration means both individuals and larger teams can work concurrently on a project, with all data securely protected, regardless of location.

### #5 Multi-Cad Data Management

This enables complete control over all CAD data, from across different CAD tools. It offers a central point for all CAD data, while also managing the dependant CAD relationships during product development.

### #6 Complete Bom Management

Manage and track all the different aspects of product development and definition. Complete BOM management covers the entire process, across all disciplines. It gives better control and offers engineers more insights into the potential impact of any changes.

### #7 Change And Configuration Management

Good communication is essential, which is where change and configuration management comes in. It makes sure that everyone is aware of each process, from designing right through to servicing, throughout the entire product lifecycle.

## 1.15 DIFFERENT VIEWS OF PLM

### 1.15.1 THE OBVIOUS BENEFITS OF PLM

For you it may be clear that PLM can help get control of a product across its lifecycle, reduce the cost and time to introduce new products, and improve products and services across their lifecycle, but it may not be clear to everybody. PLM has a wide scope and affects many people. For it to succeed, they will also have to understand what it can do and why it is needed. Bearing in mind that many people don't like to change, a little more explanation may be necessary for them.



**Different standpoint, different view**

Unfortunately for those wanting to implement PLM, there are many people who will not understand why it is necessary.Among those who won't understand will be many whose support is essential to the success of a long-term, cross-functional initiative that will have significant effects on company performance and organisation. From their position in the company, PLM may seem to have a low priority, or even be unnecessary. Those who may have difficulty in understanding the need for PLM could include the CEO, top managers, product development managers, product support managers, engineering managers, quality managers, human resource managers and IS professionals. Their reactions to talk of PLM may include:

- We're focusing on customers these days, not products. Customer focus is our message.
- It's another enterprise-wide mega-project. Everyone knows that kind of project doesn't work.
- It's just another cost. We have to focus on cost-cutting, not look for ways to spend money.
- The payback period is more than 12 months so we're not interested.
- Get Engineering to do its job properly, and you won't need PLM.

- Get Marketing to define specifications properly, and you won't need PLM.
- We don't need it. We just put a new product support organisation in place.
- We've done it. We have a product knowledge database.
- We've done it. We already have a PLM system.
- Talk about it with the CAD Manager. It's his responsibility – not ours
- We don't believe in Three Letter Acronyms (TLAs). No more acronym soup here.
- It's early days for PLM. Come back in 5 years.
- We've had enough of enterprise systems. We're trying to simplify before automating.
- PLM is just a new name invented by system vendors because PDM didn't sell. Like PDM, it won't work. Real PLM isn't a system issue, it's cultural. You can't buy it. Shrink-wrapped or otherwise.
- I understand the need for PLM, but there's no support from top management, so it doesn't interest me.
- We don't have the technical and management skills to implement PLM.
- Why worry about the actual product when it's so much easier just to change peoples' perception of it?
- I know my boss is interested in PLM, but he doesn't know how to justify its cost, so isn't pursuing it.
- Enterprise-wide technologies such as PLM are difficult to implement and have a high failure rate. I don't want that risk.

We have one guy who manages all our technical computing. There's no way he can do PLM alone.

NIH. We don't want it – it wasn't invented here, so isn't worth having. PLM is beneficial and necessary, but most people will initially fail to understand this simple message, will not react to it in the right way, and will slow down the speed at which the company can obtain the potential benefits. Many of the people whose support is necessary, and who control the resources needed for success, just won't understand. Their level of understanding will be low and it will take a long, long time to get it to a level where they will become supportive. Yet it's not possible to implement PLM without support throughout the company. It's not possible to go it alone. PLM is holistic and cross-functional. It is as much an organisational approach as a technological approach, and it needs positive involvement from people at many levels in many functions. Sometimes, a local, go-it-alone approach in one function may generate savings, but without a clear target it can just generate extra costs without providing the hoped-for benefits. The best approach that will succeed in the long-term is to fully understand the issues and convert the sceptics, and then implement across all functions. As a first step, it may be possible for one department to implement a prototype addressing one specific

PLM issue, but this should only be seen as a local, short-term demonstration of potential capability, and not the full monthly.

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**MODULE –II**

**PRODUCT DESIGN**
Engineering design, organization and decomposition in product design, product design process, methodical evolution in product design, concurrent engineering, design for 'X' and design central development model. Strategies for recovery at end of life, recycling, human factors in product design. Modelling and simulation in product

## 2.1 Engineering Design

The **engineering design process** is a common series of steps that engineers use in creating functional products and processes. The process is highly iterative - parts of the process often need to be repeated many times before another can be entered - though the part(s) that get iterated and the number of such cycles in any given project may vary.

It is a decision making process (often iterative) in which the basic sciences, mathematics, and engineering sciences are applied to convert resources optimally to meet a stated objective. Among the fundamental elements of the design process are the establishment of objectives and criteria, synthesis, analysis, construction, testing and evaluation.

## 2.2 Common stages of the engineering design process

One framing of the engineering design process delineates the following stages: research, conceptualization, feasibility assessment, establishing design requirements, preliminary design, detailed design, production planning and tool design, and production. Others, noting that "different authors (in both research literature and in textbooks) define different phases of the design process with varying activities occurring within them," have suggested more simplified/generalized models - such as problem definition, conceptual design, preliminary design, detailed design, and design communication. A standard summary of the process in European engineering design literature is that of clarification of the task, conceptual design, embodiment design, detail design. In these examples, other key aspects - such as concept evaluation and prototyping - are subsets and/or extensions of one or more of the listed steps. It's also important to understand that in these as well as other articulations of the process, different terminology employed may have varying degrees of overlap, which affects what steps get stated explicitly or deemed "high level" versus subordinate in any given model.

**Research**

Various stages of the design process (and even earlier) can involve a significant amount of time spent on locating information and research. Consideration should be given to the existing applicable literature, problems and successes associated with existing solutions, costs, and marketplace needs.

The source of information should be relevant. Reverse engineering can be an effective technique if other solutions are available on the market. Other sources of information include the Internet, local libraries, available government documents, personal organizations, trade journals, vendor catalogs and individual experts available.

**Design requirements**

Establishing design requirements and conducting requirement analysis, sometimes termed problem definition (or deemed a related activity), is one of the most important elements in the design process, and this task is often performed at the same time as a feasibility analysis. The design requirements control the design of the product or process being developed, throughout the engineering design process. These include basic things like the functions, attributes, and specifications - determined after assessing user needs. Some design requirements include hardware and software parameters, maintainability, availability, and testability.

**Feasibility**

In some cases, a feasibility study is carried out after which schedules, resource plans and estimates for the next phase are developed. The feasibility study is an evaluation and analysis of the potential of a proposed project to support the process of decision making. It outlines and analyses alternatives or methods of achieving the desired outcome. The feasibility study helps to narrow the scope of the project to identify the best scenario. A feasibility report is generated following which Post Feasibility Review is performed.

The purpose of a feasibility assessment is to determine whether the engineer's project can proceed into the design phase. This is based on two criteria: the project needs to be based on an achievable idea, and it needs to be within cost constraints. It is important to have engineers with experience and good judgment to be involved in this portion of the feasibility study.

**Concept Generation**

A concept study (conceptualization, conceptual design) is often a phase of project planning that includes producing ideas and taking into account the pros and cons of implementing those ideas. This stage of a project is done to minimize the likelihood of error, manage costs, assess risks, and evaluate the potential success of the intended project. In any event, once an engineering issue or problem is defined, potential solutions must be identified. These solutions can be found by using ideation, the mental process by which ideas are generated. In fact, this step is often termed **Ideation** or "Concept Generation." The following are widely used techniques:

- trigger word - a word or phrase associated with the issue at hand is stated, and subsequent words and phrases are evoked.
- morphological analysis - independent design characteristics are listed in a chart, and different engineering solutions are proposed for each solution. Normally, a preliminary sketch and short report accompany the morphological chart.
- synectics - the engineer imagines him or herself as the item and asks, "What would I do if I were the system?" This unconventional method of thinking may find a solution to the problem at hand. The vital aspects of the conceptualization step are synthesis. Synthesis is the process of taking the element of the concept and arranging them in the proper way. Synthesis creative process is present in every design.

- brainstorming - this popular method involves thinking of different ideas, typically as part of a small group, and adopting these ideas in some form as a solution to the problem

Various generated ideas must then undergo a **concept evaluation** step, which utilizes various tools to compare and contrast the relative strengths and weakness of possible alternatives.

## Preliminary design

The preliminary design, or high-level design includes (also called FEED or Basic design), often bridges a gap between design conception and detailed design, particularly in cases where the level of conceptualization achieved during ideation is not sufficient for full evaluation. So in this task, the overall system configuration is defined, and schematics, diagrams, and layouts of the project may provide early project configuration. (This notably varies a lot by field, industry, and product.) During detailed design and optimization, the parameters of the part being created will change, but the preliminary design focuses on creating the general framework to build the project on.

S. Blanchard and J. Fabrycky describe it as: “The ‘whats’ initiating conceptual design produce ‘hows’ from the conceptual design evaluation effort applied to feasible conceptual design concepts. Next, the ‘hows’ are taken into preliminary design through the means of allocated requirements. There they become ‘whats’ and drive preliminary design to address ‘hows’ at this lower level.”

## Detailed design

Following FEED is the Detailed Design (Detailed Engineering) phase, which may consist of procurement of materials as well. This phase further elaborates each aspect of the project/product by complete description through solid modeling, drawings as well as specifications.

## Design for manufacturability

Design for manufacturability (DFM) is the general engineering art of designing products in such a way that they are easy to manufacture.

- Operating parameters
- Operating and nonoperating environmental stimuli
- Test requirements
- External dimensions
- Maintenance and testability provisions
- Materials requirements
- Reliability requirements
- External surface treatment
- Design life
- Packaging requirements
- External marking

Computer-aided design (CAD) programs have made detailed design phase more efficient. For example, a CAD program can provide optimization to reduce volume without hindering a part's quality. It can also calculate stress and displacement using the finite element method to determine stresses throughout the part.

## Production planning

The production planning and tool design consists of planning how to mass-produce the product and which tools should be used in the manufacturing process. Tasks to complete in this step include selecting materials, selection of the production processes, determination of the sequence of operations, and selection of tools such as jigs, fixtures, metal cutting and metal or plastics forming tools. This task also involves additional prototype testing iterations to ensure the mass-produced version meets qualification testing standards.

## 2.2 Product Design Process

Introduction Product design takes a long time and a great deal of effort. It is important to target the design programme to minimise time and costs and to plan for it to be successfully completed within allocated resources. Time is very much of the essence, the minimum compatible with optimal development. In a product design plan, there are many activities to be first recognised and then coordinated; some activities are worked in sequence, some in parallel. In particular, multidisciplinary activities are focused in the same direction and coordinated in time. The master plan coordinates the various people and their mini-projects in an overall time and resource plan so that the product design can be controlled. The plan begins with the product design specifications. These include a profile of the product characteristics as defined by the consumer, the structure and composition, safety factors, convenience and aesthetics, and also indicates the manufacturing, processing and storage variables and their effects on the product qualities. Many of these product design specifications start as general descriptions; product design and process development focuses them into definite, quantitative descriptions. In the design process, the product and process development are integrated so that at the end of the design stage there is a product with the optimum qualities, and a process to produce it. A great deal of time is lost if a food product is designed under 'kitchen conditions' and then has to be redesigned as the process is developed. In food product design: important marketing factors are consumer acceptability, competitive positioning, legal regulations, ethical requirements, environmental mandates and distributor requirements; important technical factors are raw material availability, ease of processing, cost, attainability and reliability of product quality, shelf life, equipment needs, human knowledge and skills; and important financial factors are costs of manufacturing and distribution, costs of further development and the investment needed. These are considered at various parts of the design so that at the end of the product design and process development they can all be included in the feasibility report for top management. 5.2 The design process The design activities are grouped into steps: 'getting the feel', screening, ball-park studies, optimisation and scale-up of production and marketing, leading at the end to product and process specifications, marketing strategy and financial analysis as shown in  5.1. This allows control of the design process as the consumer, product and process activities are coordinated into small mini-projects with specific objectives. The activities and some of the experimental techniques in the various stages of product design and process development are shown in  5.1. The stages used in this book are 'getting the feel', screening, ball-park studies, optimisation, scale-up (production) and scale-up (marketing).

In the design, both the input variables to the process and the output variables of the product qualities are identified early in the developments. The input variables are: • raw materials: type, quality, quantity; • processing variables: types of processing, processing conditions. The output variables are: • product qualities; • product yields The levels of the input variables that are possible in the production are identified and used in the design experimentation. The level of a raw material (or ingredient) is the percentage in the formulation. Raw materials and ingredients are sometimes differentiated: raw materials as the primary products from agricultural and marine sources, and ingredients as processed materials. In this book, raw materials includes both, and mean all materials used in the process. The levels of processing variables are related to physical, chemical and microbiological measurements and also the achievable and necessary limits set by equipment and environmental conditions. There are limits set on the input variables by the needs of the product, processing and costs; there may be a lower level and a higher level, or just one of these. Identifying these levels early in the design reduces the time spent on experimentation. The product qualities wanted by the consumer are identified and quantified. Usually a range is discovered within which the product is acceptable; this sets the range within which the quality has to be controlled. Again there are usually low and high levels identified for the product qualities. The yield of product necessary to give acceptable costs is identified early in the design to direct the raw material and process experimentation. The design is a continuous study of the relationships between the input variables and the product qualities, so that the final product prototype is the optimum product under the conditions of the process. The two main parts of product design are making and testing the product prototypes, and the two important groups of people are the designers (often called developers in the food industry) and the consumers. The prototype products are tested under the standards set by the product design specifications, so that product testing needs to be organised along with the product design and the processing experiments. Regularly there is consumer input, to confirm that the product is developing characteristics as identified in the product concept and not developing characteristics which are neither wanted nor needed by the consumer. As discussed in Chapter 1, the product design ends with a final product prototype and a feasibility report: • defining the feasibility of the product for technical production, the market and the company; • anticipating the technical and market success; • assessing the financial feasibility; and • predicting associated impacts on the company and the market of various levels of product success. Gathering information for the feasibility report is an important part of the design process. 5.3 Steps in product design and process development Carrying out the design in the five successive steps listed in 5.1 goes some way towards eliminating the mistakes of choosing the wrong design and also making the product on a large scale when very little is known of the processing system. 5.3.1 'Getting the feel' This is a continuation of the development of the product concept and the product design specifications. The processing methods and conditions outlined in the product design specifications are used to make the early product prototypes, and the technical testing methods are examined for reliability and accuracy in testing both the technical product characteristics and also their relationships to the consumer product characteristics. There is a question of consumer involvement at this stage; some people advocate this strongly because it means that there is control over the design; others say that it is faster and just as accurate to use the knowledge of the designers. The choice of no consumer testing depends on the level of consumer knowledge held by the designer. The basic costing used in the company is also identified so that a simple method of determining costs can be used in the next stages of the product design. The target market was identified in the product concept stage and the consumers are selected to represent this target market(s). 5.3.2 Screening Screening reduces the wide range of raw material and processing variables to the input variables affecting important product qualities. This hastens the design. Initially the variables can be reduced using the previous knowledge of the designer and also published or company information easily available. There can still be a number of floating variables and these are studied in controlled experimentation, not 'ad hoc' try-and-see experimentation. Many experimental designs are available to screen the variables but the most common are partial factorial designs, or Plackett and Burman designs. In a Plackett and Burman design, it is possible to screen N-1 variables with N experiments. The screening experiments identify the important variables and their magnitude levels that affect the product qualities, but they are not statistically accurate and cannot quantify the relationships between the input variables and the product qualities. Some food designers have the consumers test many samples in these designs, sometimes for acceptability, but more usefully in product profile tests. Other designers use trained sensory panels. At this stage, the raw materials are being selected, and the quality, availability and costs of those raw materials are studied. There is likely a basic total cost range for the raw materials, but it is important not to select individual materials only on cost at this stage. Higher qualities of raw materials may give a unique property to the product, and also the more expensive materials may not need to be used in the same quantities as the cheaper. Sometimes there are restrictions in the company on the raw materials that are to be used; the buying department can often give some indications without restricting the design. 5.3.3 Ball-park studies In ball-park studies, the aim is to set the limits of the raw materials and the processing variables which give acceptable product qualities as judged by the consumer. By this stage, the variables are reduced in number and their outside limits are set. They are examined in factorial designs, and for raw materials in mixture designs. In factorial designs each input variable is considered at high and low levels, and the combinations of these high and low levels for all input variables are tested. In a full design all possible combinations are run, therefore for three variables the total number is 23 = 8 experiments. In food formulations, mixture designs are often used because it is impossible to vary one ingredient while holding all the others constant; in mixture designs, the sum of all the ingredients in the formulation must add to 100%. The product designer must always be aware that when they change the content of one ingredient, the proportion of the other ingredients changes, for example reducing the fat content will increase the proportion of other ingredients: carbohydrate, protein or water. With factorial designs and mixture designs, the effects of the various input variables, alone and together, on the product qualities are analysed, and mathematical relationships developed between the input variables and the product qualities. To set up the experimentation and to analyse the results, there is computer software readily available for food product development. Both technical testing and consumer testing of these product prototypes are carried out. The consumers are testing for acceptability and the technical tests are examining the chemical, microbiological, physical and sometimes the sensory properties of the products. Accuracy and reliability are important considerations in this testing, both for studying the effects of the input variables on the product qualities and for developing the quality assurance programme. The total processing costs of these product prototypes are compared to identify the effects of the input variables on the costs, and to check that the costs are within the target cost range

Think Break 5.1 Steps in product design and process development: consumer testing Discuss the advantages and disadvantages of consumers testing the prototypes in 'Getting the feel', 'Screening' and 'Ball-park' experimentation. For what types of products – packaging change, product improvement, product line extension, product innovation – would you use consumer testing and at what stages in the product and process development.

Optimisation Here the aim is to optimise the overall product quality by determining the levels of the input variables which will give the best possible product quality. The problem is that often when optimising one product quality, another product quality is less than optimum. So it is a case of setting the relative importance of product qualities, and for the most important product qualities studying the formulation and processing variables to find the optimum. But the limits that are acceptable across all the product qualities need to be known so that during the optimising experiments none of the other product qualities become unacceptable. . For raw material formulations, linear programming can be used to optimise a number of product qualities and costs with the amounts of raw materials in the formulation held between upper and lower levels. 5.3.5 Scale-up Scale-up (or ramp-up) of both the production and the marketing is the last stage of the product design and process development. The production scale-up is the in-plant test to verify that the product can be made at the quality and quantity required, and the marketing scale-up is a large consumer test to verify that the target consumers will buy the product and what marketing strategy will encourage this buying. The aim of the processing scale-up is to determine the optimum production process for product quality, product yield, process control and costs. If the previous design research has combined the product and the process, this can be achieved without too many problems. But if the process has been ignored, then there can be disastrous problems. For example, if some of the intermediate materials have never been pumped during the design experimentation, then they could break down during scale-up. The scale-up can be either on a pilot plant or short production runs on the main plant. If it is a new process, or there is to be quite extensive experimentation, then the scale-up is conducted on a pilot or small-scale plant. If the process is only an adaptation of the present production, then the scale-up is conducted on the main production plant. The decisions on the type of scale-up are often much influenced by cost; the production trial can cost a great deal if the product cannot be sold and this restricts the use of the production plant until the final stage. But if there is no investment money to build a pilot plant then the production run may be the only scale-up available. The question can often be asked as to when the scale-up from the laboratory bench to the small plant to the production line should be carried out. A great deal of time can be spent perfecting a product in the laboratory, only to find that it is impossible to duplicate this in the plant. If the product is rushed from the laboratory to the production line, then there can be a great deal of raw material and product discarded at a substantial cost. Knowledge of the interrelationship of the processing variables and the product qualities can reduce these failures. EVOP (evolutionary operations) are used in optimising the process variables, especially if using the production line in scale-up. EVOP is a way of plant operation that tests small changes in the process variables in a simple factorial design. It continuously changes the process variables until optimum product qualities are reached, but only slowly so that the product can be used for large scale testing or even sold. The marketing scale-up aims to define the market, describe the market strategy to reach this market and predict the possible sales revenues for the product. Possible market channels are studied and the market channel suitable for reaching the target consumers and for the company is chosen. The price range related to the production costs, competitors' pricing and company policy is tested with consumers to see how it affects their buying intentions. Also the final product concept (the product proposition) is built up from the final prototype product, the packaging design and consumer studies. The definitions of the product, price and market channel are used not only to develop the aims and methods for the promotion of the product but are also the basis for planning the marketing mix during product commercialisation. The final prototype product from the production scale-up and the various parts of the marketing strategy are tested in a large-scale consumer test where the consumers test the product in their usual environment and are interviewed about the marketing strategy.

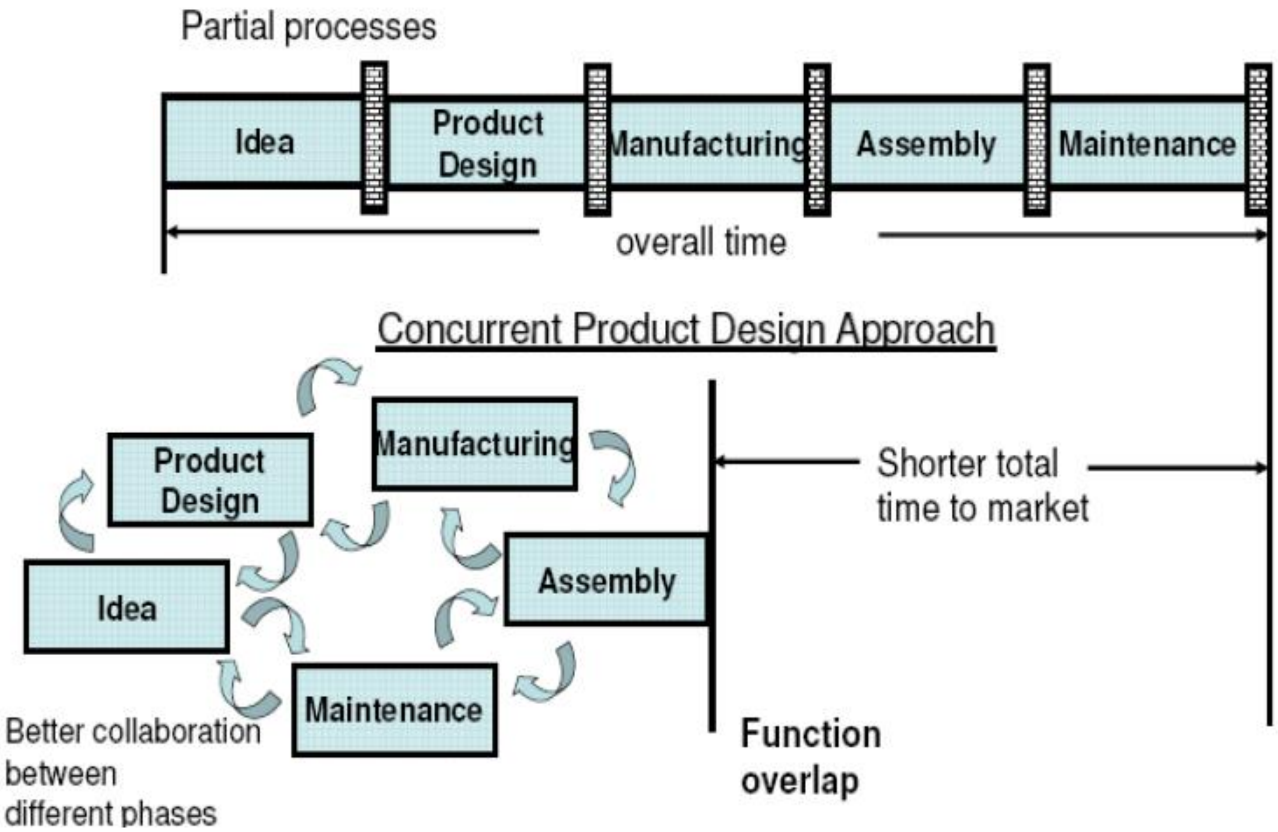
Think Break 5.2 Activities in product design and process development: rice risotto The company has decided to produce a rice risotto, a dry flavoured mix to which only boiling water is added to give a quick snack, similar in use to instant noodles. Identify some of the important activities in the design of this product.

## 2.3 **Concurrent Engineering:**

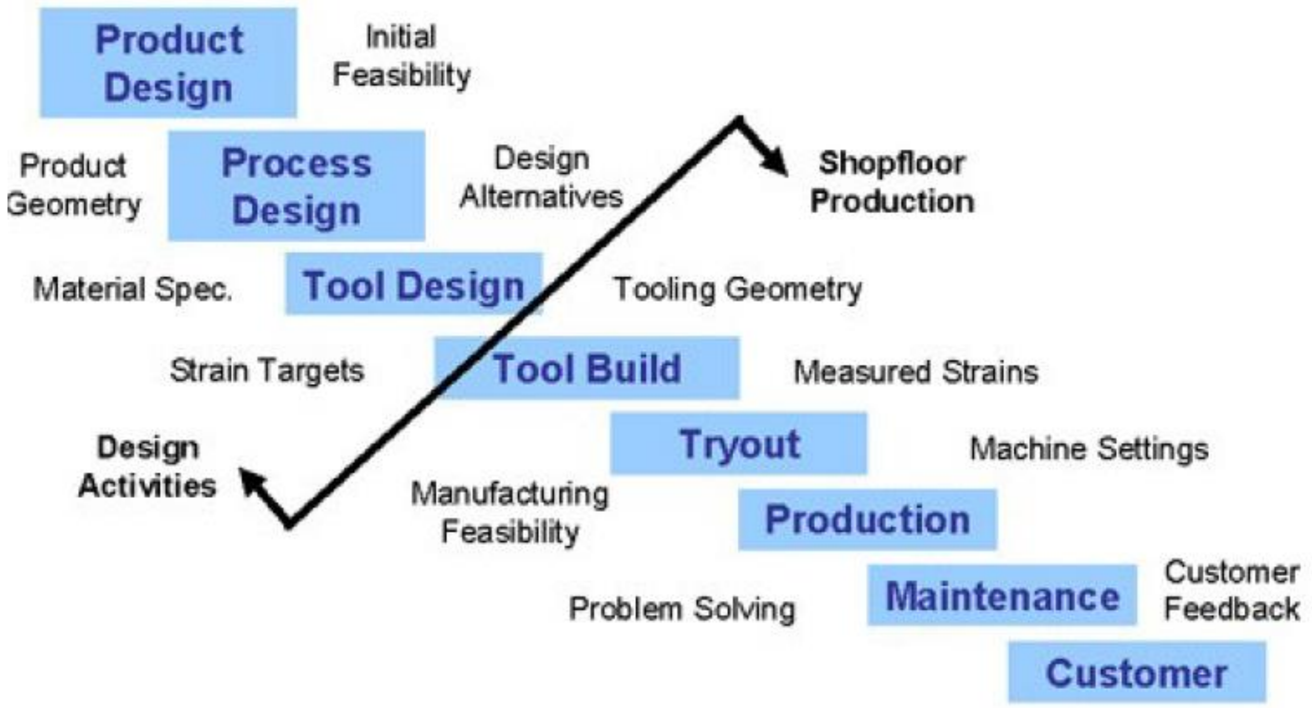
Is a strategy where all the tasks involved in product development are done in parallel. Collaboration between all individuals, groups and departments within a company.

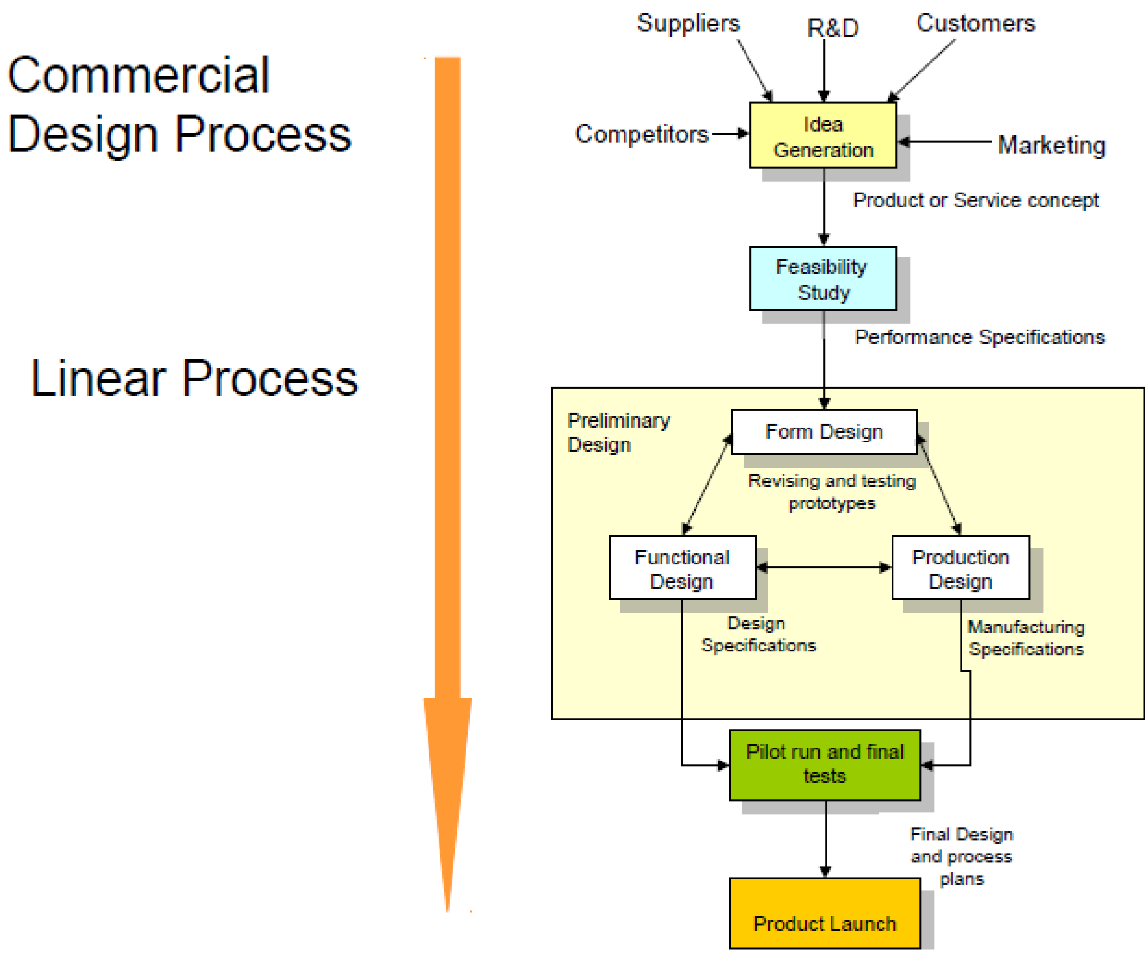
- Customer research

- Designers
- Marketing
- Accounting
- Engineering



## Concurrent Engineering






**2.4 Design for Excellence** or **Design For Excellence** (**DfX** or **DFX**), are terms and expansions used interchangeably in the existing literature, where the X in design for X is a variable which can have one of many possible values. In many fields (e.g., very-large-scale integration (VLSI) and nanoelectronics) X may represent several traits or features including: manufacturability, power, variability, cost, yield, or reliability. This gives rise to the terms design for manufacturability (DfM, DFM), design for inspection (DFI), design for variability (DfV), design for cost (DfC). Similarly, other disciplines may associate other traits, attributes, or objectives for X.

Under the label design for X, a wide set of specific design guidelines are summarized. Each design guideline addresses a given issue that is caused by, or affects the traits of, a product. The design guidelines usually propose an approach and corresponding methods that may help to generate and apply technical knowledge to control, improve, or even invent particular traits of a product. From a knowledge-based view, the design guideline represents an explicit form of knowledge, that contains information about *knowing-how-to* (see Procedural knowledge). However, two problems are prevalent. First, this explicit knowledge (i.e., the design guidelines) were transformed from a tacit form of knowledge (i.e., by experienced engineers, or other specialists). Thus, it is not granted that a freshman or someone who is outside the subject area will comprehend this generated explicit knowledge. This is because it still contains embedded fractions of knowledge or respectively include non-obvious assumptions, also called context-dependency (see e.g. Doz and Santos, 1997:16–18). Second, the traits of a product are likely to exceed the knowledge base of one human. There exists a wide range of specialized fields of engineering, and considering the whole life cycle of a product will require non-engineering expertise. For this purpose, examples of design guidelines are listed in the following.

## 2.5 Rules, guidelines, and methodologies along the product life cycle

DfX methodologies address different issues that may occur in one or more phase of a product life cycle:

- Development phase
- Production phase
- Use phase
- Disposal phase

Each phase is explained with two dichotomous categories of tangible products to show differences in prioritizing design issues in certain product life cycle phases:

- Consumer durables
- Capital goods

Non-durables that are consumed physically when used, e.g. chocolate or lubricants, are not discussed. There also exist a wide range of other classifications because products are either a) goods b) service or c) both (see OECD and Eurostat, 2005:48). Thus, one can also refer to whole product, augmented product, or extended product. Also the business unit strategy of a firm are ignored, even though it significantly influences priority-setting in design.

## 2.6 Modeling and Simulation (M&S)

Modeling and simulation (M&S) is the use of a physical or logical representation of a given system to generate data and help determine decisions or make predictions about the system. M&S is widely used in the social and physical sciences, engineering, manufacturing and product development, among many other areas.

Applications of modeling and simulation include:

- Creating models of weather systems, simulating behavior based on available data to generate predictive information for forecasts. A hurricane forecast model, for example, is designed to predict a given storm's track and intensity, as well as related events such as storm surges.
- Simulating the effect of severe weather events like hurricanes and storm surges on infrastructure to guide the design of more resilient systems.
- Creating a program to model a social situation and observing the behavior of individuals in the simulation when the program runs. Social simulations can be used to yield predictive data about how things happen in real-world environments, such as how social norms develop.
- Simulating how a physical change to a system will affect its performance. For example, NASA has explored drone aerodynamics with logical models simulating air pressures and currents around the rotors. That information could potentially be used to develop designs that reduce turbulence, which would make the vehicles quieter in operation.

**MODULE –III**

**PRODUCT DEVELOPMENT**
**New Product Development, Structuring new product development, building decision support system, Estimating market opportunities for new product, new product financial control, implementing new product development, market entry decision, launching and tracking new product program. Concept of redesign of product.**

## 3.1 NEW PRODUCT DEVELOPMENT

In business and engineering, **new product development** (**NPD**) covers the complete process of bringing a new product to market. A central aspect of NPD is product design, along with various business considerations. New product development is described broadly as the transformation of a market opportunity into a product available for sale. The product can be tangible (something physical which one can touch) or intangible (like a service, experience, or belief), though sometimes services and other processes are distinguished from "products." NPD requires an understanding of customer needs and wants, the competitive environment, and the nature of the market. Cost, time and quality are the main variables that drive customer needs. Aiming at these three variables, innovative companies develop continuous practices and strategies to better satisfy customer requirements and to increase their own market share by a regular development of new products. There are many uncertainties and challenges which companies must face throughout the process. The use of best practices and the elimination of barriers to communication are the main concerns for the management of the NPD

## 3.2 PROCESS STRUCTURE

The product development process typically consists of several activities that firms employ in the complex process of delivering new products to the market. A process management approach is used to provide a structure. Product development often overlaps much with the engineering design process, particularly if the new product being developed involves application of math and/or science. Every new product will pass through a series of stages/phases, including ideation among other aspects of design, as well as manufacturing and market introduction. In highly complex engineered products (e.g. aircraft, automotive, machinery), the NPD process can be likewise complex regarding management of personnel, milestones and deliverables. Such projects typically use an integrated product team approach. The process for managing large-scale complex engineering products is much slower (often 10-plus years) than that deployed for many types of consumer goods.

The product development process is articulated and broken down in many different ways, many of which often include the following phases/stages:

1. **Fuzzy front-end** (FFE) is the set of activities employed before the more formal and well defined requirements specification is completed. Requirements speak to what the product should do or have, at varying degrees of specificity, in order to meet the perceived market or business need.
2. **Product design** is the development of both the high-level and detailed-level design of the product: which turns the what of the requirements into a specific how this particular product will meet those requirements. This typically has the most overlap with the engineering design process, but can also include industrial design and even purely aesthetic aspects of design. On the marketing and planning side, this phase ends at pre-commercialization analysis stage.
3. **Product implementation** often refers to later stages of detailed engineering design (e.g. refining mechanical or electrical hardware, or software, or goods or other product forms), as well as test process that may be used to validate that the prototype actually meets all design specifications that were established.
4. **Fuzzy back-end** or commercialization phase represent the action steps where the production and market launch occur.

The front-end marketing phases have been very well researched, with valuable models proposed. Peter Koen et al. provides a five-step front-end activity called front-end innovation: opportunity identification, opportunity analysis, idea genesis, idea selection, and idea and technology development. He also includes an engine in the middle of the five front-end stages and the possible outside barriers that can influence the process outcome. The engine represents the management driving the activities described. The front end of the innovation is the greatest area of weakness in the NPD process. This is mainly because the FFE is often chaotic, unpredictable and unstructured. Engineering design is the process whereby a technical solution is developed iteratively to solve a given problem The design stage is very important because at this stage most of the product life cycle costs are engaged. Previous research shows that 70–80% of the final product quality and 70% of the product entire life-cycle cost are determined in the product design phase, therefore the design-manufacturing interface represent the greatest opportunity for cost reduction. Design projects last from a few weeks to three years with an average of one year. Design and Commercialization phases usually start a very early collaboration. When the concept design is finished it will be sent to manufacturing plant for prototyping, developing a Concurrent Engineering approach by implementing practices such as QFD, DFM/DFA and more. The output of the design (engineering) is a set of product and process specifications – mostly in the form of drawings, and the output of manufacturing is the product ready for sale. Basically, the design team will develop drawings with technical specifications representing the future product, and will send it to the manufacturing plant to be executed. Solving product/process fit problems is of high priority in information communication design because 90% of the development effort must be scrapped if any changes are made after the release to manufacturing.

### 3.3 NEW PRODUCT DEVELOPMENT PROCESS

1. **New Product Strategy** – Innovators have clearly defined their goals and objectives for the new product.
2. **Idea Generation** – Collective brainstorming ideas through internal and external sources.
3. **Screening** – Condense the number of brainstormed ideas.

4. **Concept Testing** – Structure an idea into a detailed concept.
5. **Business Analysis** – Understand the cost and profits of the new product and determining if they meet company objectives.
6. **Product Development** – Developing the product.
7. **Market Testing** – Marketing mix is tested through a trial run of the product.
8. **Commercialization** – Introducing the product to the public. Models

Conceptual models have been designed in order to facilitate a smooth process.

- **IDEO approach.** The concept adopted by IDEO, a design and consulting firm, is one of the most researched processes in regard to new product development and is a five-step procedure These steps are listed in chronological order:
  1. Understand and observe the market, the client, the technology, and the limitations of the problem;
  2. Synthesize the information collected at the first step;
  3. Visualise new customers using the product;
  4. Prototype, evaluate and improve the concept;
  5. Implementation of design changes which are associated with more technologically advanced procedures and therefore this step will require more time
- **BAH Model.** One of the first developed models that today companies still use in the NPD process is the Booz, Allen and Hamilton (BAH) Model, published in 1982. This is the best known model because it underlies the NPD systems that have been put forward later. This model represents the foundation of all the other models that have been developed afterwards. Significant work has been conducted in order to propose better models, but in fact these models can be easily linked to BAH model. The seven steps of BAH model are: new product strategy, idea generation, screening and evaluation, business analysis, development, testing, and commercialization.
- **Stage-gate model.** A pioneer of NPD research in the consumer's goods sector is Robert G. Cooper. Over the last two decades he conducted significant work in the

area of NPD. The Stage-Gate model developed in the 1980s was proposed as a new tool for managing new products development processes. This was mainly applied to the consumer's goods industry. The 2010 APQC benchmarking study reveals that 88% of U.S. businesses employ a stage-gate system to manage new products, from idea to launch. In return, the companies that adopt this system are reported to receive benefits such as improved teamwork, improved success rates, earlier detection of failure, a better launch, and even shorter cycle times – reduced by about 30%. These findings highlight the importance of the stage-gate model in the area of new product development.

- **Lean Start-up approach.** Over the last few years, the Lean Startup movement has grown in popularity, challenging many of the assumptions inherent in the stage-gate model.
- **Exploratory product development model.** Exploratory product development, which often goes by the acronym Expand, is an emerging approach to new product development. Consultants Mary Drotar and Kathy Morrissey first introduced Expand at the 2015 Product Development and Management Association annual meeting and later outlined their approach in the Product Development and Management Association's magazine Visions. In 2015, their firm Strategy2Market received the trademark on the term "Exploratory PD. Rather than going through a set of discrete phases, like the phase-gate process, exploratory product development allows organizations to adapt to a landscape of shifting market circumstances and uncertainty by using a more flexible and adaptable product development process for both hardware and software. Where the traditional phase-gate approach works best in a stable market environment, Expand is more suitable for product development in markets that are unstable and less predictable. Unstable and unpredictable markets cause uncertainty and risk in product development. Many factors contribute to the outcome of a project, and Expand works on the assumption that the ones that the product team doesn't know enough about or are unaware of are the factors that create uncertainty and risk. The primary goal of Expand is to reduce uncertainty and

risk by reducing the unknown. When organizations adapt quickly to the changing environment (market, technology, regulations, globalization, etc.), they reduce uncertainty and risk, which leads to product success. Expand is described as a two-pronged, integrated systems approach. Drotar and Morrissey state that product development is complex and needs to be managed as a system, integrating essential elements: strategy, portfolio management, organization/teams/culture, metrics, market/customer understanding, and process.

**Idea Generation**

The first stage of the New Product Development is the idea generation. Ideas come from everywhere, can be of any form, and can be numerous. This stage involves creating a large pool of ideas from various sources, which include –

- **Internal sources** – many companies give incentives to their employees to come up with workable ideas.
- **SWOT analysis** – Company may review its strength, weakness, opportunities and threats and come up with a good feasible idea.
- **Market research** – Companies constantly reviews the changing needs, wants, and trends in the market.
- **Customers** – Sometimes reviews and feedbacks from the customers or even their ideas can help companies generate new product ideas.
- **Competition** – Competitors SWOT analysis can help the company generate ideas.

**Idea Screening**

Ideas can be many, but good ideas are few. This second step of new product development involves finding those good and feasible ideas and discarding those which aren't. Many factors play a part here, these include –

- Company's strength,
- Company's weakness,
- Customer needs,
- Ongoing trends,

- Expected ROI,
- Affordability, etc.

**Concept Development & Testing**

The third step of the new product development includes concept development and testing. A concept is a detailed strategy or blueprint version of the idea. Basically, when an idea is developed in every aspect so as to make it presentable, it is called a concept.

All the ideas that pass the screening stage are turned into concepts for testing purpose. You wouldn't want to launch a product without its concept being tested.

The concept is now brought to the target market. Some selected customers from the target group are chosen to test the concept. Information is provided to them to help them visualize the product. It is followed by questions from both sides. Business tries to know what the customer feels about the concept. Does the product fulfil the customer's need or want? Will they buy it when it's actually launched?

Their feedback helps the business to develop the concept further.

**3.4 Business Strategy Analysis & Development**

The testing results help the business in coming up with the final concept to be developed into a product.

Now that the business has a finalized concept, it's time for it to analyse and decide the marketing, branding, and other business strategies that will be used. Estimated product profitability, marketing mix, and other product strategies are decided for the product.

Other important analytics includes

- Competition of the product
- Costs involved
- Pricing strategies
- Breakeven point, etc.

**Product Development**

Once all the strategies are approved, the product concept is transformed into an actual tangible product. This development stage of new product development results in building up of a prototype or a limited production model. All the branding and other strategies decided previously are tested and applied in this stage.

**Test Marketing**

Unlike concept testing, the prototype is introduced for research and feedback in the test marketing phase. Customers feedback are taken and further changes, if required, are made to the product. This process is of utmost importance as it validates the whole concept and makes the company ready for the launch.

**Commercialization**

The product is ready, so should be the marketing strategies. The marketing mix is now put to use. The final decisions are to be made. Markets are decided for the product to launch in. This stage involves briefing different departments about the duties and targets. Every minor and major decision is made before the final introduction stage of the new product development.

## 3.5 Building Decision Support System User Interface

Decision support systems are now widely used in organizations and military across the world, helping decision makers apply analytical, statistical and scientific techniques to decision making. In recent years, there popularity has significantly increased because of their ability to execute, interpret, analyze and suggest.

Decision support systems can be used in the areas of economic forecasting, risk management, manufacturing automation, supply chain management, healthcare, data warehousing, demographic trends and forecasts, resource allocation, etc. The growing popularity of decision support systems is due to their capability to help decision makers balancing conflicting objectives and allocating scarce resources optimally.

Though decision support systems are known to make the whole process of decision making easier and speedier, their own development is a complex and time consuming process. Building a DSS user interface requires a very high level of expertise in technology, programming, decision making, project management, and user experience and user interface design. Plus, it requires a close and unswerving collaboration of the analysts, programmers, decision makers, finance specialists and end users.

**Building DSS User Interface**

In the previous article, we learnt about ROMC approach to user interface design. Since each DSS has a different purpose, defining representations, operations, and memory and control aids are of absolute importance before beginning to develop a DSS user interface. The usefulness, validity and applicability of a DSS depend on the design elements of a user interface.

**A good user interface design must ensure that:**

- The screen design is aesthetically pleasing
- The layouts are symmetrical
- The arrangement of options/menus is appropriate
- The screen layout is easy to understand and use
- The design doesn't need to be artistic but it should certainly be visually pleasing
- Working on it is easy and enjoyable

Therefore, a Decision Support System user interface developer must:

- Get started with all significant information in hand. As a DSS is customized to the needs of end users, it's not a previously defined package. This means that a DSS user interface developer must steer clear of assumptions and postulations. Rather he or she must rely on neat specifications.
- Be able to respond quickly to the needs of end users. A decision support system needs to be modified or evolved quickly as per the directions of the decision maker who is going to use the system. The designing of user interface should be such that it facilitates changes whenever required.
- Take into account the idiosyncrasies of the problems to be solved. Each DSS is developed to solve particular types of problems. Therefore, a user interface developer is expected to understand the peculiarity of the problems to be solved using DSS. And on the basis of this, he or she must be able to determine what

kind of input a user must feed and how and what kind of output the system must produce.

- Pay attention to the order of priority while designing the software. This typically includes four steps. i) Design user interface, focusing on the dialogue that takes place between user and machine. ii) Design operations and commands that will be used to carry out the operations. iii) Define what happens when the user gives a command. iv) Work backward and create the program.

While a DSS user interface developer works on building the software, the focus must constantly be on - who the user is; what the user will do with the system; what type of decisions the user makes; and what aid the user expects from a DSS.

Comments on Design Elements

As user interface development takes place, the developer must keep a tab on the way information will be presented to the end user. Design elements play a crucial role in forming user experience. Here are few tips that should be kept in mind:

- Visual presentation of data is important, as it helps users visualize the relationship between two or more elements.
- Graphs, charts, hierarchy, diagrams, flowcharts and maps should be used in reports, performance sheets, planning, designing and allocation.
- Augment the use of color in a way that it enhances the overall appearance of the system.
- Allow users to have some control of the functions, such as color adjustments, themes, home screen, wall papers, menu style, patterns, etc.
- Build guidance mechanisms, in order to make it easy for users to manipulate the system.
- Offer process guidance help, just in case the user feels stuck.
- The software system should be responsive enough to offer suggestions to the users, helping them optimally use the system.

The bottom line is that a DSS user interface developer should make it a point that the system provides decision makers with enough discretion and prudence. The system must let them choose the way they want to use it.

Guidelines for Dialogue and User Interface design

The design of a computerized system determines whether it will be used or not. Over the period of time, the researchers, DSS analysts and designers and decision makers have gather several important points that may be considered as principles or guidelines for dialogue and user interface design.

Although the user interface is central to the system development but the totality of experience also plays an important role. You must be cautious about user experience and ensure that the decision maker or the end user attains utmost satisfaction.

**Here are 10 user interface design rules that you must follow when designing one:**

1. **Consistency:** A decision support system software must look, feel and act similar throughout. The color combination, theme, menu display and other visuals must be consistent. It makes a DSS look organized and well thought out.
2. **Reduce Information Overload:** The main objective of a decision support system is to reduce information overload and simplify things to the extent possible. Probably, this is why most organizations use computerized systems to aid decision making. The human memory is subject to a limitation when it comes to information processing and learning commands. Where appropriate, the design should be minimized and commands should be displayed and the sequence of actions should be shortened.
3. **Create Aesthetically Appealing yet Minimalist Interface Design:** The interface should be appealing; however, you need not show your artistic side. It must be balanced, soothing, interactive and responsive.
4. **Informative Feedback:** Users look forward to informative feedback about the command they have given or action they have performed. Minor commands may offer modest feedback, whereas concrete feedback should be offered for infrequent actions.

5. **Design Interactions:** Each interaction should have a sequence or an order – beginning, middle and end. This keeps a track on the flow of the dialogue.
6. **Anticipate Errors:** You need to anticipate possible errors that a user can make when using the decision support system. Think of simple and comprehendible ways to detect errors and to guide users on what to do now. At some places, the system must make users aware of what errors they are going to make by pressing a command.
7. **Permit Action Reversal:** Include 'undo'. Sometimes, users make mistakes unintentionally. But inability to reverse the action may build anxiety in users. Give them the flexibility to undo what they did, whether knowingly or unknowingly. It gives them the confidence to try out new things.
8. **Give Users Control of the System:** People using a decision support system want to control each aspect of the system. Inability to control makes them anxious and unconfident. Give them control of the system and let them explore it as much as they want.
9. **Provide Accelerators:** As decision makers use a DSS more frequently, they don't want to offer same information each time they log into the system. Provide them with accelerators to shorten the interactions and increase the pace. Offer abbreviations and automation commands that accelerate the entire process of decision making.
10. **Provide Documentation and Help Capabilities:** A DSS although is not incomplete if it doesn't provide documentation capabilities but to users it may seem incomplete. Such capabilities are desirable because most users want to document major points or something that catches their attention.

An effective user interface makes a system easier to use. It eliminates anxiety and fear of technology and promotes its use. A decision support designer must keep all the above guidelines when designing a user interface.

Factors Influencing User Interface Design Success

There are a lot of factors that influence the success of a user interface design. A DSS designer is expected to recognize and consider these factors when designing a user interface for a decision support system. This is done to:

- Eliminate/reduce the fatigue of working on a system
- Reduce the learning time of DSS users
- Reduce the chances of errors made by end users
- Keep users motivated to use the decision support system
- Offer users the ease to recall

So, **here are the factors influencing UI design success**. Take a look:

- **Execution Time:** Why does a decision maker use computerized system to aid decision making? Obviously, to reduce execution time! As a DSS designer, you must try reduce the execution time for a command given and action performed. Maximize the pace of execution to minimize the wastage of time.
- **Versatility:** A decision support system must be resourceful enough to perform the entire range of tasks that a decision maker needs to perform when making a decision using DSS. Moreover, it should be flexible enough to integrate new tasks whenever needs arises.
- **Adaptability:** A decision support system should be smart enough to adapt according to the most prominent habits of its user. This means it needs to be self-tailoring or customizing in itself. It may seem impractical, but in reality it is not. Rather this is what is expected from a smart decision making system.
- **Learning Time:** A DSS user interface should be simple enough to reduce the learning time of its users, so that they can use it to its full capacity as soon as possible.
- **Uniformity of Command:** As said earlier, a DSS user interface must have a uniform theme throughout. It should offer the same look and feel and command throughout.
- **Quality of Help:** When a decision maker is user a DSS built by you, he or she expects complete on and off line support from you. The success of a DSS

depends upon the quality of support offered. Recognize what user may do on/with the DSS and offer self-help manuals both online and offline.

- **Memory Load:** A person has limitations when it comes to remembering numbers. The idea is not to bombard the user with too many statistical or numerical data interpretations at one time. A good UI design takes the memory load off the user mind.
- **Ease of Recall:** If a user comes back to DSS after long, it must help him/her recall what was done previously. It helps them achieve the same pace in a shortened time.
- **Fatigue:** Mental fatigue occurs because of the complexity of the design. Keep things simple and keep the commands visual so that the user doesn't need to remember anything.
- **Errors:** Anticipate errors that a user may perform when using a decision support system. Provide them the control to reverse the action and help to guide them what to do next.

Designing decision support system user interface is the toughest part of the development cycle. It's the most important element as it establishes the communication between the machine and the human. The use of visual elements and simple screen designs can add a great deal to the success of a DSS.

Estimating market opportunities for new product

Whenever we launch a new product or a service, we fear whether it has enough market potential. It is known very well that you need to **calculate market potential** before you launch a product or a service. This article will help you determine 5 basic factors which can give you an idea on whether or not you have a good Market potential.

Market potential, quite simply, is the total demand for a product in a given business environment. So if you were going to write a book on business, you will check all the books written on business and the sales they had. That is your market potential. Off course, determining the actual values are very difficult and that is where you need to use various tips and tactics.

## 3.6 LET US GO THROUGH THE 5 ELEMENTS TO DETERMINE MARKET POTENTIAL.

### 1) Market Size

The first and most important factor to consider while determining market potential is the market size of your product. Market size is the total market sales potential of all companies put together. So if i planned on launching a new soap or Shampoo, then all the different companies such as HUL and P&G are my competitors. And the combined sales of soaps, including branded and non branded products is my complete market size.

If you look at consumer level, the market size is generally huge. Market size would be in Millions or billions too. But as you go down to industrial level, Market size can be anything from a lakh to a thousand or even a hundred.

If you were a dealer of industrial ball bearings, then all the companies which are in manufacturing are potentially your customers. So if you find out the number of industries in your region, that is the ideal market size which you can target when launching a new Ball bearing product. Mind you, this is 100% market size. The market captured by you and who is going to be your future customer is a different story altogether.

The best way to get market size is to contact local research agencies if it is a small business. If it is a large business, it is better to take Market research data from companies like Nielson or IMRB. Determination of market size is the first step to determine market potential.

### 2) Market growth rate

The PC market as compared to the laptop market or the smartphone market is declining. So if you are a company which makes PC’s, then you have to be aware that you are entering an declining market. Instead, if you have the potential, why not enter the Laptop market or the Smartphone market.

The ongoing trend in the industry is important as it can forecase the future of your product. Initially, books were all the rage, but now they have been replaced by Ebooks and there is hardly any need for the physical books (though people still love to read them).

When you study market growth, you have to forecast based on the differences between product line extensions and a completely new concept in the Market. Samsung has the Samsung galaxy series which is a pioneer series in Samsung. Naturally, whenever a new product line extension of Samsung Galaxy is launched, it will sell in the market. But will a new product line sell at the same pace? So the Market growth rate is subjective and it depends on the type of product you are going to launch.

Market growth rate can be determined by checking the facts and figures of the last 5 years of the industry that you are in. Many top websites will give you such data. In fact, even newspapers do frequent analysis of which are the industries that are growing and at what percentage. Today, if i were to enter the E-commerce industry, it will be a wise choice because the industry is growing by leaps and bounds. However, 10 years down the line, a new technology might be invented, which makes E-commerce buying obsolete.

**3) Profitability**

Going back to the E-commerce example, many small businesses have a mixed feedback for E-commerce businesses. Some say that the market is huge and there is a lot of potential. But others say that they have suffered huge losses because of the amount of packaging and the transport costs involved for shipping across country. These are both perspectives and both of them are correct.

Determining and forecasting your profitability is important to understand the market potential. If the business is going to give low profitability, then the volumes need to be high (ex – fmcg products) or if the business is going to give low volumes, then the profit needs to be higher (ex – industrial goods).

Calculation of profitability to determine Market potential can use three main elements

- ROI – Return on investment

- ROS – Return on sales
- RONA – Return on net assets
- ROCE – Return on capital employed

You can use any of the calculations mentioned above to calculate the likelihood of profitability and to determine how profitable the industry or product is going to be.

**4) Competition**

You need to know and understand the competition in an industry to determine the market potential for the product you are going to launch. If the industry has high competition, the entry barriers are going to be high and at the same time, establishing yourself will require deep pockets. You might have to lower the price of your products even though you are giving higher value. This requires that you have enough money to take hits till the time competition leaves the market.

This is exactly what happens when top brands enter industries which were dominated by Smaller players. Today, small retailers are suffering under the brunt of large multi national sellers. Nonetheless, this does not mean small businesses have stopped establishing themselves. They are using different strategies to attract customers to their businesses. One such strategy is good customer service, which is missing in large corporations.

When competition is low, market awareness will be low as well. An example can be taken of industrial refrigeration products, where the competition is low, but the product knowledge is low as well. So your competitor is equally likely to influence the potential buyer as you are. Differentiation will be minimal because there is no need of investing in differentiation. In such a market, the companies which actually differentiate, literally dominate the market they are in.

Determining market potential requires you to understand the market standing of various competitors and it also requires that you have the necessary plans up your sleeves to understand how to tackle these competitors when the time comes.

**5) Product and consumer type**

Is your product a repeat buying product or one time sale only? In the above examples, Soap and shampoo is a repeat buying product. But once you buy a refrigerator, i doubt you will need another for the next 10 years. So in your whole lifetime, you will buy 8-10 refrigerators at the max. But in a year, you are likely to buy 40-50 soaps individually. That's 300-400 soaps per individual in their livelihood. Multiply that by a billion and you can understand the market potential of the soap industry.

So how frequently is your product going to be bought again? Many toothpaste companies actively push the consumer to brush twice in a day. One of the reasons is that your teeth will be better. But another reason is that the toothpaste will be consumed faster and you will buy another toothpaste soon. Hence the push for brushing twice daily!!

Is your product completely new in the market? How likely is the customer to accept and adopt the same and what are the hurdles to be faced in product adoption? Can you forecast them right now? Because that will help in determining market potential.

The above 5 elements will give you a very good idea about the market potential of your product, irrespective of whether the product exists in the market or you are going to launch a new one. Remember – this does not apply to innovative products because the market size and growth rate of innovative products is unknown.

## 3.7 RESEARCH AND DEVELOP IDEAS, NEW PRODUCTS AND SERVICES

**Financing new product or service development**

Securing adequate funding is one of the biggest obstacles many entrepreneurs face. If you're launching your business on the back of a new product or service, it's important to build into your financial forecasts a generous margin for contingencies and the unexpected.

It's not worth investing money in a new product or service and then running out before your business has got off the ground. See how to choose the right finance when starting up.

Analysing the costs of new product and service development

Once you've developed and tested your new product or service concept, it will require a detailed business analysis. This step of the process helps to:

- determine the costs involved in the development
- forecast the profits you may make from your product or service
- When doing a business analysis, you will want to:
- estimate your product price, including the discounted or minimum sale price
- identify your product's full market potential
- forecast the sales volume and likely profits
- identify your break-even point
- consider the full the lifecycle of your product in the market

A thorough business analysis will help you determine how much money you might need to secure or borrow for your product or service development, and what return on investment is likely to be.

Controlling costs in product or service development

It's essential to keep a close eye on costs when you develop new products and services to avoid them spiraling out of control. You should:

- estimate development costs in advance
- monitor spending throughout the development process
- introduce phased investment – eg release funds for each new development stage once the previous one has been successfully completed

There are two main ways to estimate costs:

- a **top-down approach** where you consider previous comparable projects and use them as a benchmark
- a **bottom-up approach** where all team members agree the costs they expect to incur with one project manager, who will then estimate the total cost

Remember that your costs could include staffing, materials, technology, product design, market research, prototyping and overhead costs.

It is important to plan any investment and control your costs carefully. Before making investment decisions, consider how much your business stands to gain from the new product or service. Weigh this against any risks you face.

## 3.8 STEP PROCESS PERFECTS NEW PRODUCT DEVELOPMENT

**Step 1: Generating**

Utilizing basic internal and external SWOT analyses, as well as current marketing trends, one can distance themselves from the competition by generating ideologies which take affordability, ROI, and widespread distribution costs into account.

Lean, mean and scalable are the key points to keep in mind. During the NPD process, keep the system nimble and use flexible discretion over which activities are executed. You may want to develop multiple versions of your road map scaled to suit different types and risk levels of projects.

**Step 2: Screening The Idea**

Wichita, possessing more aviation industry than most other states, is seeing many new innovations stop with Step 2 – screening. Do you go/no go? Set specific criteria for ideas that should be continued or dropped. Stick to the agreed upon criteria so poor projects can be sent back to the idea-hopper early on.

Because product development costs are being cut in areas like Wichita, "prescreening product ideas," means taking your Top 3 competitors' new innovations into account, how much market share they're chomping up, what benefits end consumers could expect etc. An interesting industry fact: Aviation industrialists will often compare growth with metals markets; therefore, when Boeing is idle, never assume that all airplanes are grounded, per se.

**Step 3: Testing The Concept**

As Gaurav Akrani has said, "Concept testing is done after idea screening." And it is important to note, it is different from test marketing.

Aside from patent research, design due diligence, and other legalities involved with new product development; knowing where the marketing messages will work best is often the biggest part of testing the concept. Does the consumer understand, need, or want the product or service?

**Step 4: Business Analytics**

During the New Product Development process, build a system of metrics to monitor progress. Include input metrics, such as average time in each stage, as well as output metrics that measure the value of launched products, percentage of new product sales and other figures that provide valuable feedback. It is important for an organization to be in agreement for these criteria and metrics.

Even if an idea doesn't turn into product, keep it in the hopper because it can prove to be a valuable asset for future products and a basis for learning and growth.

**Step 5: Beta / Marketability Tests**

Arranging private tests groups, launching beta versions, and then forming test panels after the product or products have been tested will provide you with valuable information allowing last minute improvements and tweaks. Not to mention helping to generate a small amount of buzz. Word Press is becoming synonymous with beta testing, and it's effective; Thousands of programmers contribute code, millions test it, and finally even more download the completed end-product.

**Step 6: Technicalities + Product Development**

Provided the technical aspects can be perfected without alterations to post-beta products, heading towards a smooth step 7 is imminent. According to Akrani, in this step, "The production department will make plans to produce the product. The marketing department will make plans to distribute the product. The finance department will provide the finance for introducing the new product".

As an example; In manufacturing, the process before sending technical specs to machinery involves printing MSDS sheets, a requirement for retaining an ISO 9001 certification (the organizational structure, procedures, processes and resources needed to implement quality management.)

In internet jargon, honing the technicalities after beta testing involves final database preparations, estimation of server resources, and planning automated logistics. Be sure to have your technicalities in line when moving forward.

**Step 7: Commercialize**

At this stage, your new product developments have gone mainstream, consumers are purchasing your good or service, and technical support is consistently monitoring progress. Keeping your distribution pipelines loaded with products is an integral part of this process too, as one prefers not to give physical (or perpetual) shelf space to competition. Refreshing advertisements during this stage will keep your product's name firmly supplanted into the minds of those in the contemplation stages of purchase.

**Step 8: Post Launch Review and Perfect Pricing**

Review the NPD process efficiency and look for continues improvements. Most new products are introduced with introductory pricing, in which final prices are nailed down after consumers have 'gotten in'. In this final stage, you'll gauge overall value relevant to COGS (cost of goods sold), making sure internal costs aren't overshadowing new product profits. You continuously differentiate consumer needs as your products age, forecast profits and improve delivery process whether physical, or digital, products are being perpetuated.

**Remember: The Process Is Loose**

The entire new product development process is an ever evolving testing platform where errors will be made, designs will get trashed, and loss could be recorded. Having your entire team working in tight synchronicity will ensure the successful launch of goods or services, even if reinventing your own wheel. Productivity during product development can be achieved if, and only if, goals are clearly defined along the way and each process has contingencies clearly outlined on paper.

New tactics are required to get the notice you deserve. So here are some steps for a successful launch in these fickle times:

1. **Start early**. Don't expect reporters to write about you when you want. Get a head start and begin preparing long before you plan to launch. A rolling launch is a great way to keep the conversation going. Start your outreach activities 6-8 weeks before the official launch date and then keep the news going up to, and beyond the official launch date. The steps below describe how to do this.
2. **Make the product or service available to important influencers** as a first step. Influencers can be friendly customers, prospects, or even bloggers who have an sizable online presence. Encourage these people to use your product or service and then write review articles or posts. These folks are also great resources to talk to analysts about your offering pre-launch.
3. **Brief industry analysts** during this early phase as well. Scheduling calls with these folks takes time so do this early. Invest the time to write compelling briefing requests. These guys are busy, so you will want to make sure your meeting request clearly states why it is worth their time to hear about your offering.
4. **Seed the social space with "leaks."** Target people who are naturally eager to learn about your offering. For example, 'coming soon' tweets and 'leaked' photos of your product create an aura of intrigue that builds interest. Apple is a master of this technique.
5. **Don't expect a "big bang" release** unless your product or service is truly revolutionary or if you are Microsoft or Apple. Unless you have a massive launch event planned, the official launch date should only signify the day your product is actually available.
6. **Keep the release rolling**. You don't know when reporters will have time to write, so give them some opportunity to write about the offering after the official launch date. Continue to produce fresh news like announcements concerning novel uses of the product, customer stories, details about how the offering provides return on investment (ROI) to customers, etc.

7. **Do something unusual** during the release cycle. Some examples include creating a funny video, doing a stunt centered around an industry event, publishing a survey that supports the value of your product, or creating an interesting infographic that describes the need for your product. As an example, for a recent product launch, I created a mock public service announcement (PSA) website that warned of the 'dangers' of using our new mobile product while walking. The irony created an enormous buzz around the launch and even led to a huge spike in free product downloads. You can check it out here.
8. **Get partners involved**. Channel and marketing partners who have a financial stake in the success of the launch are natural allies. The more people that are talking about the release, the better chances it will get pickup.
9. **Make it easy for people to learn more about your product** with free trials, downloads, product videos, and demos.
10. **Ignore the elements of the launch that do not drive business.** Unless your offering appeals to a mass consumer audience, don't focus on the number of Facebook likes and Twitter followers you collect. Rather, use these social channels for more meaningful engagement. See who is talking about your offering online and then make contact with them. See how these folks can help you further promote your offering within their social circles.



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**MODULE –IV**

**TECHNOLOGY FORECASTING**

Technological change, methods of technology forecasting, relevance trees, morphological methods, flow diagram and combining forecast of technologies Integration of technological product innovation and product development in business processes within enterprises, methods and tools in the innovation process according to the situation,

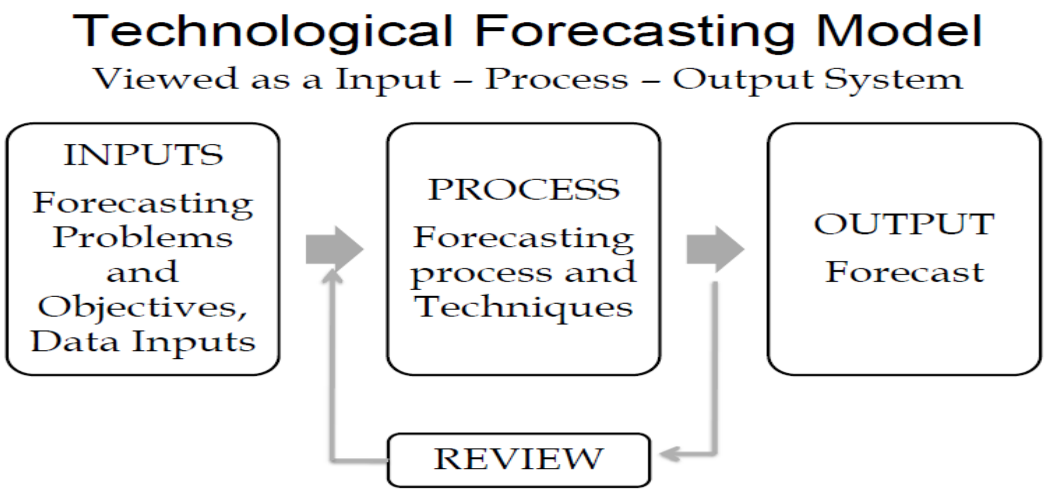
## 4.1 Technological Forecasting

Introduction to Technology Forecasting

- Definitions of Technology Forecasting
- Why Technology Forecasting?
- Model of Technology Forecasting
- Elements of Technology Forecasting
- Objectives of Technology Forecasting

**Technology Forecasting**

- Three definitions of technology forecasting from leading experts
- Technology forecasting is a group of techniques that predict the direction, character, rate, implication, and impact of technological advances -Vanston
- A prediction of the future characteristics of useful machines, procedures, or techniques -Martino
- Anticipation of the character, intensity, and timing of changes in technology -Porter
- Why Technological Forecasting?
- It is Indispensable
- It improves Quality of Decision making
- Scanning the technological environment
- Anticipating emerging technological changes
- identifying suitable technologies by evaluating various alternatives
- Planning for future technology needs




**4.1.1 Elements of Technological Forecasting**

1. Forecasting problems & objectives
2. Data inputs for forecasting
3. Forecaster
4. Forecasting process
5. Forecasting techniques
6. Forecast (output)
7. Review Mechanism

## 4.1.2 Objectives for Technology *Forecasting*

- The first step in a technology forecasting project is to determine the purpose the forecast is to serve.
- Vanston suggests five purposes
- Projections of the rates at which new technologies will replace older ones
- Important to companies dependent on the old as well as the new technology

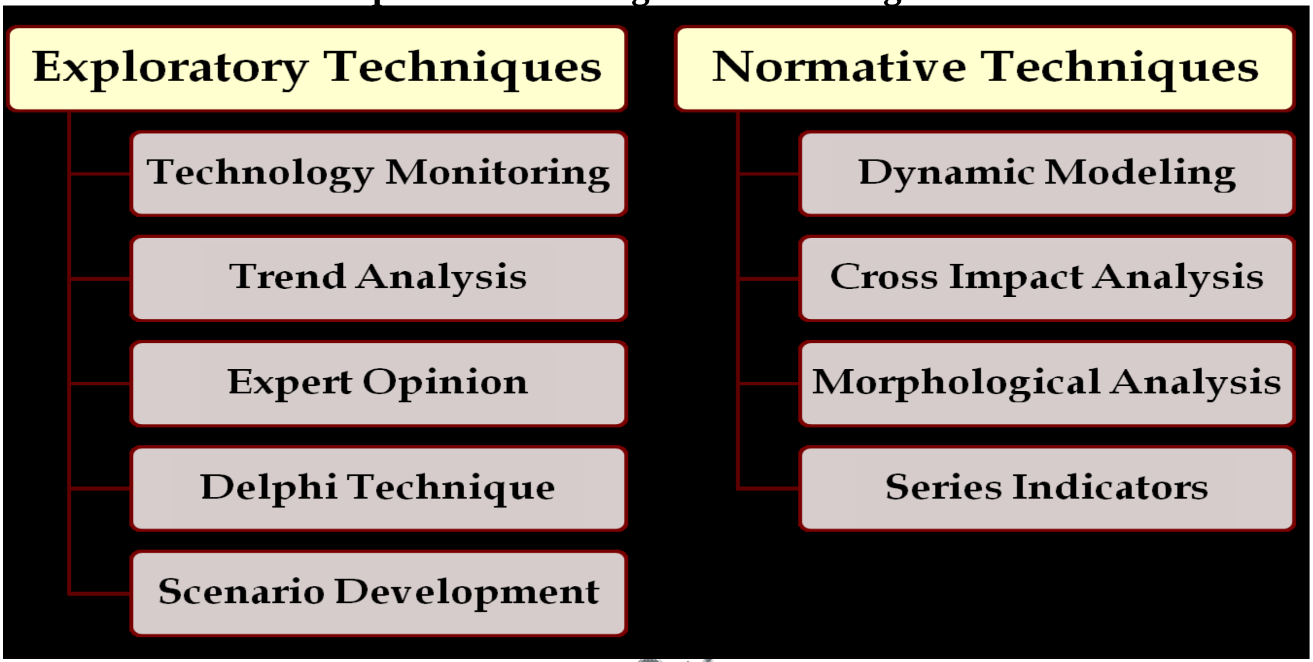
Assistance in the Management of Technical Research and Development

- Forecasting the technology emergence process can facilitate allocation of R&D resources
- Evaluation of the Present Value of Technology Under Development
- Forecasting the commercial value of a technology in the development process

Identification and Evaluation of New Products or Processes that May Present the Organization with New Opportunities or Threats

- Forecasting new business opportunities or threats to present markets Analysis of New Technical Developments that Might Change Organizational Strategies or Operations
- Forecasting technology changes that might change the internal operations of the organization itself.

**4.2 Methods or Techniques of Technological Forecasting**




**Qualitative Vs Quantitative Methods**

| | Qualitative Methods | Quantitative Methods |
|---|---|---|
| 1. Characteristics | Based on human judgment, opinions; subjective and nonmathematical. | Based on mathematics; quantitative in nature. |
| 2. Strengths | Can incorporate latest changes in the environment and "inside information." | Consistent and objective; able to consider much information and data at one time. |
| 3. Weaknesses | Can bias the forecast and reduce forecast accuracy. | Often quantifiable data are not available. Only as good as the data on which they are based. |

**4.3.1 Exploratory: 1. Technology Monitoring**

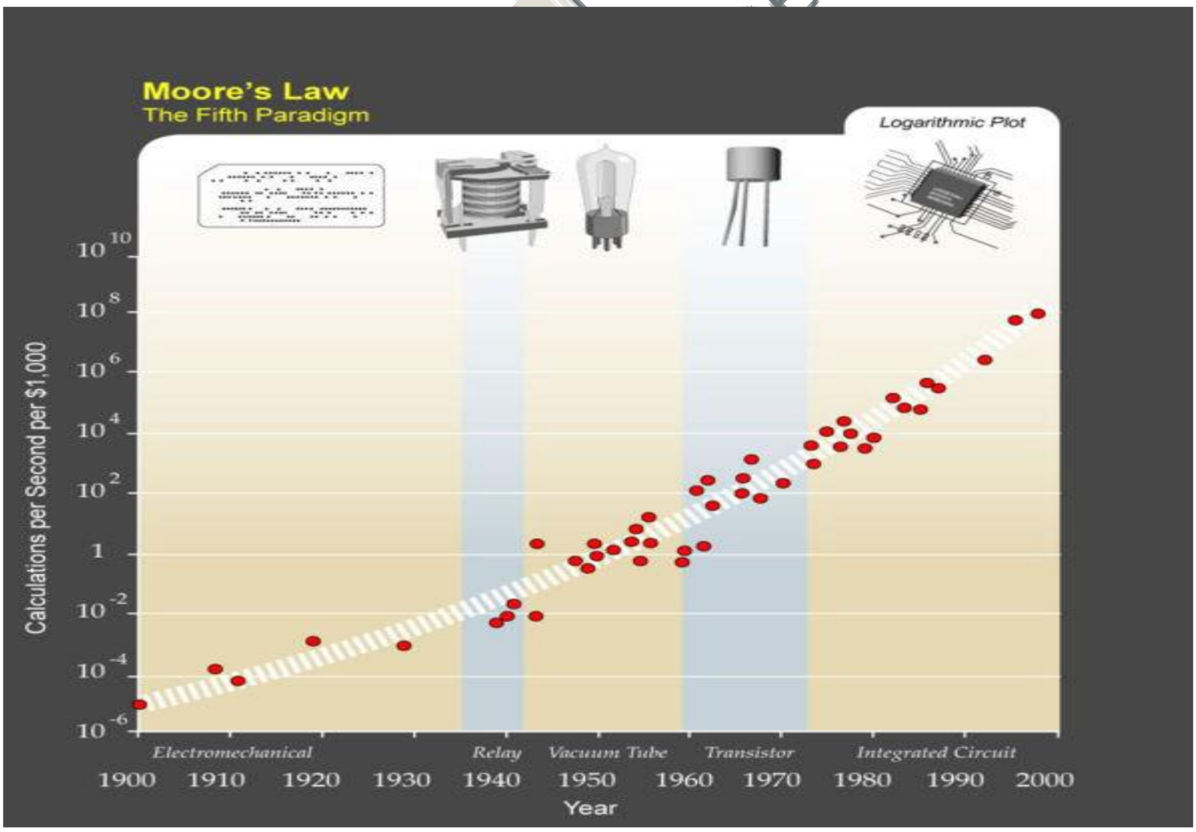
- Having good Scanning and Intelligence System

- It is the process of scanning the environment for information about the subject of forecast.
- "Environmental scanning can be thought of as the central input to futures research." The sources of information are indentified and then information is gathered, filtered, processed and
- structured for using forecasting.
- The method is simple and give quick results.
- Sometimes, information overload may result in confusion and delays.
- There should not be difficult and costly to gather information.

**4.3.2. Trend Analysis**

It uses mathematical and statistical techniques to extent time series data in the future

 Trend analysis is a broad term that encompasses economic forecasting models and techniques such as regression, exponential smoothing and growth curve fitting



**4.3.3. Expert Opinion**

It collects opinion of chosen experts in a particular area and arrives at a forecast

- This methods include forecasting or understanding technological development via intensive consultation with subject matter experts.
- Identify experts in an area exist, data are lacking and difficult to identify a model
- Forecasting may be wrong when questions posed to them are ambiguous and unclear

**4.3.4 Delphi Technique**

It was originally developed at Ran Corporation of the USA in the late 1940s by Olaf Helmer

- It consist of an attempt to arrive at a consensus in an uncertain area by questioning a group of experts repeatedly.
- Leader first supplies questions to the experts who are located at different places for their response
- Each expert is given the opportunity to react to the information or considerations advanced by others.
- It reduces Helo Effect, Bandwagon Effect and Ego Involvement with publicity expressed opinion



**4.3.5 Scenario Development**

A set of snapshot of some aspect of the future situation

- They encompass the believable range for chosen aspect
- A set on imaginative descriptions are developed based on qualitative and quantitative data
- It mixes imagination, intuition and scientific data analysis
- They are most useful on forecasting and in communicating complex, highly uncertain situations to non-technical audience.

**4.3.6 Normative : 1. Dynamic Modeling**

A model is a simplified representation of some part of the real world

- Models range from flow diagrams, simple equations, and scale models, to sophisticated computer simulations

 Model can exhibit the future behavior of complex systems simply by isolating important system aspects from unessential details

### 4.3.7 Cross Impact Analysis

Researchers identify a set of key trends those with high importance or probability

 If event A occurs, what will be the impact on all other trends ?

 The success of the method depends on the choice of events which are related, also the ability to interpret the developments is important

## 4.4 Morphological Analysis

It was developed by the well – known Swiss astronomer wicky in his work in the field of jet engines

- An attractive characteristic of morphological research is the assessment of the likelihood that a future technology will be realized ( or a square in the morphological box)
- All solutions of the morphological box should be examined for their feasibility and analyzed and evaluated with respect to the purposes to be achieved

## 4.5 Series Indicators

 Each company establishes favorite indices of those general economic conditions most relevant to its product/technology category.

 These indices should be examined for any indicators that may affect the life of the technology

 There are three general categories of indicators as given under

1. Leading Indicators
2. Simultaneous (Coincident) Indicators
3. Lagging Indictors

### Choosing a Forecasting Technique

No single technique works in every situation

 Two most important factors

 Cost

 Accuracy

- Other factors include the availability of:
- Historical data
- Computers
- Time needed to gather and analyze the data
- Forecast horizon

**4.6 Innovation Methods, Techniques and Tools**

Tools for innovation come in many different shapes and sizes. There are many useful tools such as mind-maps, collaboration software, modeling software, knowledge and idea management systems, etc.. These all have a role in the innovation process but they are not innovation tools *per se* as they implement generic activities. Their usefulness is directly dependent on the methodologies employed, not on the tool itself. The tools of most interest to the innovator are those that directly enable, support and direct the right methods and practices for the innovation process. These are the tools that directly lead to the knowledge necessary for understanding the community, technology and solution domains from which value can be derived. Inovo's Tool Suite is listed below. Links to descriptions of specific tools are also provided. Keep checking back as these wiki pages are updated on a regular basis.

Community Building Tools - Tools to find the right knowledge communities and individuals within those communities to understand needs and desires

- **Context Selection Tool** - A tool to select where to begin. Defining the 'exploration' space and identifying the focus and boundaries for opportunity discovery efforts.
- **Knowledge-Community Exploration Tool** - A tool that uses social networks and 'small world' methods to identify rich veins of knowledge and experience. This includes spanning hidden social networks by contacting the connectors, the weak links, and other high-value individuals.
- **Technology Mapping Tool** - A tool to find 'what is possible' by deconstructing a technology into its essential effects and constraints. Useful for identifying and engaging with knowledge experts as well as direct customers.

- Elicitation and Synthesis Tools - Tools to uncover and capture the tacit and explicit knowledge held by individuals. These tools help to detect meaningful patterns in the raw data and to synthesize a holistic picture.
- **Individual Engagement Tool** - Interview tools and methods using laddering, pyramiding, metaphor elicitation and LOCA (Latent Observation Constant Annoyance) to uncover tacit knowledge and experience from individuals
- **Community Member Profiling Tool** - A means to capture, organize and synthesize engagement dialogs.
- **Opportunity Mapping Tool** - A system to map needs and desires into meaningful patterns from individual profiles. This includes identifying the relevant effect, experience and outcome dimensions essential to creating value.
- Persona Creation and Modeling Tools - Tools to develop persona profiles and models that are relevant to the domain being explored.
- **Persona Adoption Modeling (PAM) Tool** - A tool to identify the distinct needs and desire patterns including the Kano profiles of the different personas and build them into a software simulator to predict the response of personas to alternative concepts and situations
- **Persona Definition Tool** - A concise means to capture and share prose definitions of personas. This includes graphical maps of the top needs and desires as well as the outcome and experience profiles
- **Concept Effect Mapping Tool** - Deconstruction of a concept into its essential effects profile
- **Adoption Dynamics Forecast** - A quick analysis of the persona's adoption behavior with respect to a specific concept over time using measures of Uniqueness, Relevance and Ubiquity
- Ecosystem Modeling Tools - Tools to create an understanding of the complex business ecosystem using system dynamics modeling methods.

- **Value Triangulation Tool** - A tool to quickly assess the economic potential of an opportunity from three perspectives: supply side, demand side, and 'persona' side
- **Value Event Modeling Tool** - A tool that enables estimating value development in highly ambiguous, uncertain and changing situations (e.g., in the front-end). This is an alternative to Discounted Cash Flow (DCF) analysis, and is useful when the discount rate alone is inadequate to express all the risk.
- **Ecosystem Economy Modeling Tool** - A tool that captures the complex and dynamic interactions and influences within a business ecosystem to enable scenario development and decision making
- Ideation Tools - Tools that support and facilitate the creative brainstorming and idea creation process
- **Springboard** - A structured and dynamic presentation of 'all that is known', using persona definitions and technology maps, to bring the entire internal community up to the same level of knowledge.
- **GOES Ideation Session** - Creation of new ideas and concepts using the Generate - Organize - Expand - Select technique that results in relevant, focused and high potential concepts
- **Storyboarding** - Visualizing a future with the new concept. Understanding the user experience before the product or service exists
- **Design Burst** - Collaborative concept design using charrette-based methods
- Concept Auction Decision Support Tool - Using the wisdom of crowds to assess competing alternatives and gain insight into which have the most value and support. These tools support the human activities necessary for an effective innovation process.

## 4.7 TECHNOLOGY FORECASTING METHODOLOGIES

As was discussed earlier, technology forecasting methodologies are processes used to analyze, present, and in some cases, gather data. Forecasting methodologies are of four types:

- Judgmental or intuitive methods,
- Extrapolation and trend analysis,
- Models, and
- Scenarios and simulations.

### 4.7.1 Judgmental or Intuitive Methods

Judgmental methods fundamentally rely on opinion to generate a forecast. Typically the opinion is from an expert or panel of experts having knowledge in fields that are relevant to the forecast. In its simplest form, the method asks a single expert to generate a forecast based on his or her own intuition. Sometimes called a “genius forecast,” it is largely dependent on the individual and is particularly vulnerable to bias. The potential for bias may be reduced by incorporating the opinions of multiple experts in a forecast, which also has the benefit of improving balance. This method of group forecasting was used in early reports such as *Toward New Horizons* (von Karman, 1945).

Forecasts produced by groups have several drawbacks. First, the outcome of the process may be adversely influenced by a dominant individual, who through force of personality, outspokenness, or coercion would cause other group members to adjust their own opinions. Second, group discussions may touch on much information that is not relevant to the forecast but that nonetheless affects the outcome. Lastly, groupthink[4] can occur when forecasts are generated by groups that interact openly. The shortcomings of group forecasts led to the development of more structured approaches. Among these is the Delphi method, developed by the RAND Corporation in the late 1940s.

*The Delphi Method*

The Delphi method is a structured approach to eliciting forecasts from groups of experts, with an emphasis on producing an informed consensus view of the most probable future. The Delphi method has three attributes—anonymity, controlled feedback, and statistical group response[5]—that are designed to minimize any detrimental effects of group interaction (Dalkey, 1967). In practice, a Delphi study begins with a questionnaire soliciting input on a topic. Participants are also asked to provide a supporting argument for their responses.

Groupthink: the act or practice of reasoning or decision making by a group, especially when characterized by uncritical acceptance or conformity to prevailing points of view. Groupthink occurs when the pressure to conform within a group interferes with that group's analysis of a problem and causes poor decision making. Available at http://www.answers.com/topic/groupthink. Last accessed June 11, 2009.

"Statistical group response" refers to combining the individual responses to the questionnaire into a median response.

participants, who are then asked if they would care to modify their initial responses based on those of the other experts. It is believed that during this process the range of the answers will decrease and the group will converge toward a "correct" view of the most probable future. This process continues for several rounds, until the results reach predefined stop criteria. These stop criteria can be the number of rounds, the achievement of consensus, or the stability of results (Rowe and Wright, 1999).

The advantages of the Delphi method are that it can address a wide variety of topics, does not require a group to physically meet, and is relatively inexpensive and quick to employ. Delphi studies provide valuable insights regardless of their relation to the status quo. In such studies, decision makers need to understand the reasoning behind the responses to the questions. A potential disadvantage of the Delphi method is its emphasis on achieving consensus (Dalkey et al., 1969). Some researchers believe that potentially valuable information is suppressed for the sake of achieving a representative group opinion (Stewart, 1987).

Because Delphi surveys are topically flexible and can be carried out relatively easily and rapidly, they are particularly well suited to a persistent forecasting system. One might imagine that Delphi surveys could be used in this setting to update forecasts at regular intervals or in response to changes in the data on which the forecasts are based.

### 4.7.2 Extrapolation and Trend Analysis

Extrapolation and trend analysis rely on historical data to gain insight into future developments. This type of forecast assumes that the future represents a logical extension of the past and that predictions can be made by identifying and extrapolating the appropriate trends from the available data. This type of forecasting can work well in certain situations, but the driving forces that shaped the historical trends must be carefully considered. If these drivers change substantially it may be more difficult to generate meaningful forecasts from historical data by extrapolation. Trend extrapolation, substitution analysis, analogies, and morphological analysis are four different forecasting approaches that rely on historical data.

### 4.7.3 Trend Extrapolation

In trend extrapolation, data sets are analyzed with an eye to identifying relevant trends that can be extended in time to predict capability. Tracking changes in the measurements of interest is particularly useful. For example, Moore's law holds that the historical rate of improvement of computer processing capability is a predictor of future performance (Moore, 1965). Several approaches to trend extrapolation have been developed over the years.

### 4.7.4 Gompertz and Fisher-Pry Substitution Analysis

Gompertz and Fisher-Pry substitution analysis is based on the observation that new technologies tend to follow a specific trend as they are deployed, developed, and reach maturity or market saturation. This trend is called a growth curve or S-curve (Kuznets, 1930). Gompertz and Fisher-Pry analyses are two techniques suited to fitting historical trend data to predict, among other things, when products are nearing maturity and likely to be replaced by new technology (Fisher and Pry, 1970; Lenz, 1970).

**Analogies**

Forecasting by analogy involves identifying past situations or technologies similar to the one of current interest and using historical data to project future developments. Research has shown that the accuracy of this forecasting technique can be improved by using a structured approach to identify the best analogies to use, wherein several possible analogies are identified and rated with respect to their relevance to the topic of interest (Green and Armstrong, 2004).

Green and Armstrong proposed a five-step structured judgmental process. The first step is to have an administrator of the forecast define the target situation. An accurate and comprehensive definition is generated based on

advice from unbiased experts or from experts with opposing biases. When feasible, a list of possible outcomes for the target is generated. The next step is to have the administrator select experts who are likely to know about situations that are similar to the target situation. Based on prior research, it is suggested that at least five experts participate (Armstrong, 2001). Once selected, experts are asked to identify and describe as many analogies as they can without considering the extent of the similarity to the target situation. Experts then rate how similar the analogies are to the target situation and match the outcomes of the analogies with possible outcomes of the target. An administrator would use a set of predefined rules to derive a forecast from the experts' information. Predefined rules promote logical consistency and replicability of the forecast. An example of a rule could be to select the analogy that the experts rated as the most similar to the target and adopt the outcome implied by that analogy as the forecast (Green and Armstrong, 2007).

**Morphological Analysis (TRIZ)**

An understanding of how technologies evolve over time can be used to project future developments. One technique, called TRIZ (from the Russian *teoriya resheniya izobretatelskikh zadatch,* or the "inventor's problem-solving theory"), uses the Laws of Technological Evolution, which describe how technologies change throughout their lifetimes because of innovation and other factors, leading to new products, applications, and technologies. The technique lends itself to forecasting in that it provides a structured process for projecting the future attributes of a present-day technology by assuming that the technology will change in accordance with the Laws of Technological Evolution, which may be summarized as follows:

- *Increasing degree of ideality*. The degree of ideality is related to the cost/benefit ratio. Decreasing price and improving benefits result in improved performance, increased functionality, new applications, and broader adoption. The evolution of GPS from military application to everyday consumer electronics is an example of this law.
- *Nonuniform evolution of subsystems*. The various parts of a system evolve based on needs, demands, and applications, resulting in the nonuniform evolution of the subsystem. The more complex the system, the higher the likelihood of nonuniformity of evolution. The development rate of desktop computer subsystems is a good example of nonuniform evolution. Processing speed, disk capacity, printing quality and speed, and communications bandwidth have all improved at nonuniform rates.
- *Transition to a higher level system*. "This law explains the evolution of technological systems as the increasing complexity of a product or feature and multi-functionality" (Kappoth, 2007). This law can be used at the subsystem level as well, to identify whether existing hardware and components can be used in higher-level systems and achieve more functionality. The evolution of the microprocessor from Intel's 4004 into today's multicore processor is an example of transition to a higher-level system.
- *Increased flexibility*. "Product trends show us the typical process of technology systems evolution is based on the dynamization of various components, functionalities, etc." (Kappoth, 2007). As a technology moves from a rigid mode to a flexible mode, the system can have greater functionality and can adapt more easily to changing parameters.
- *Shortening of energy flow path*. The energy flow path can become shorter when energy changes form (for example, thermal energy is transformed into mechanical energy) or when other energy parameters change. The transmission of information also follows this trend (Fey and Rivin, 2005). An example is the transition from physical transmission of text (letters, newspapers, magazines, and

books), which requires many transformational and processing stages, to its electronic transmission (tweets, blogs, cellular phone text messaging, e-mail, Web sites, and e-books), which requires few if any transformational or processing stages.

- *Transition from macro- to microscale*. System components can be replaced by smaller components and microstructures. The original ENAIC, built in 1946 with subsystems based on vacuum tubes and relays, weighed 27 tons and had only a fraction of the power of today's ultralight laptop computers, which have silicon-based subsystems and weigh less than 3 pounds.

The TRIZ method is applied in the following stages (Kucharavy and De Guio, 2005):

- *Analysis of system evolution*. This stage involves studying the history of a technology to determine its maturity. It generates curves for metrics related to the maturity level such as the number of related inventions, the level of technical sophistication, and the S-curve, describing the cost/benefit ratio of the technology. Analysis of these curves can help to predict when one technology is likely to be replaced by another.
- *Road mapping*. This is the application of the above laws to forecast specific changes (innovations) related to the technology.
- *Problem formulation*. The engineering problems that must be addressed to realize the evolutionary changes predicted in the road mapping stage are then identified. It is in this stage that technological breakthroughs needed to realize future technologies are specified.
- *Problem solving*. Many forecasts would terminate in the problem formulation stage since it is generally not the purpose of a forecast to produce inventions. In spite of this, TRIZ often continues. This last stage involves an attempt to solve the engineering problems associated with the evolution of a technology. Although the attempt might not result in an actual invention, it is likely to come up with valuable information on research directions and the probability of eventual success in overcoming technological hurdles.

**Models**

These methods are analogous to developing and solving a set of equations describing some physical phenomenon. It is assumed sufficient information is available to construct and solve a model that will lead to a forecast at some time in the future; this is sometimes referred to as a "causal" model. The use of computers enables the construction and solution of increasingly complex models, but the complexity is tempered by the lack of a theory describing socioeconomic change, which introduces uncertainty. The specific forecast produced by the model is not as important as the trends it reveals or its response to different inputs and assumptions.

The following sections outline some model-based techniques that may be useful for forecasting disruptive technology. Some of them were used in the past for forecasting technology, with varying success.

**Theory of Increasing Returns**

Businesses that produce traditional goods may suffer from the law of diminishing returns, which holds that as a product becomes more commonplace, its marginal opportunity cost (the cost of foregoing one more unit of the next best alternative) increases proportionately. This is especially true when goods become commoditized through increased competition, as has happened with DVD players, flat screen televisions, and writable compact discs. Applying the usual laws of economics is often sufficient for forecasting the future behavior of markets. However, modern technology or knowledge-oriented businesses tend not to obey these laws and are instead governed by the law of increasing returns (Arthur, 1996), which holds that networks encourage the successful to be yet more successful. The value of a network explodes as its membership increases, and the value explosion attracts more members, compounding the results (Kelly, 1999). A positive feedback from the market for a certain technological product is often rewarded with a "lock-in." Google, Facebook, and Apple's iPhone and iPod are examples of this. A better product is usually unable to replace an older product immediately unless the newer product offers something substantially better in multiple dimensions, including price, quality, and convenience of use. In contrast, this does not happen in the "goods" world, where a slightly cheaper product is likely to threaten the incumbent product.

Although the law of increasing returns helps to model hi-tech knowledge situations, it is still difficult to predict whether a new technology will dislodge an older product. This is because success of the newer product depends on many factors, some not technological. Arthur mentions that people have proposed sophisticated techniques from qualitative dynamics and probability theory for studying the phenomenon of increasing returns and, thus, perhaps to some extent, disruptive technologies.

**Chaos Theory and Artificial Neural Networks**

Clement Wang and his colleagues propose that there is a strong relationship between chaos theory and technology evolution (Wang et al., 1999). They claim that technology evolution can be modeled as a nonlinear process exhibiting bifurcation, transient chaos, and ordered state. What chaos theory reveals, especially through bifurcation patterns, is that the future performance of a system often follows a complex, repetitive pattern rather than a linear process.

## MODULE –V

**PRODUCT BUILDING AND STRUCTURES**
Virtual product development tools for components, machines, and manufacturing plants: 3D CAD systems, digital mock-up, model building, model analysis, production (process) planning, and product data technology, Product structures: Variant management, product configuration, material master data, product description data, Data models, Life cycles of individual items, status of items.

**5.1 Virtual product development** (**VPD**) is the practice of developing and prototyping products in a completely digital 2D/3D environment. VPD has four main components:

- Virtual product design (3D shape, 2D graphics/copy)
- Virtual product simulation (drop test, crush test, etc.)
- Virtual product staging (retail space planning, consumer research and behavior analysis)
- Digital manufacturing (process planning, assembly/filling virtualization, plant design).

VPD typically takes place in a collaborative, web-based environment that brings together designers, customers/consumers, and value chain partners around a single source of real-time product "truth". VPD enables practitioners to arrive at the right idea more quickly, and to accurately predict its performance in manufacturing and retail settings, ultimately minimizing time to value, market failure potential, and product development costs.

Virtual process planning is a relatively new concept for manufacturing companies, although the concept has been in use for the construction industry for several years. BIM (building information modeling) is the system used by many constructions, architectural and contracting firms. The detail and scheduling aspects are some of the more valuable aspects of the system. By utilizing virtual process planning, the entire production process can be designed to both maximize efficiency and avoid the trial and error method employed by most manufacturers.

Various software exists with differing levels of information. The placement of work stations, inventory, personnel and equipment can be valuable for space planning. The interaction of the previously mentioned can also be investigated, allowing the user to identify potential issues from safety, quality and ergonomic standpoints.

Virtual Product Development, VPD, is a result of constant efforts in a direction to overcome the limitations of conventional testing procedures. VPD allows a designer to take important design decisions at early stages based on test results, giving control over cost. ‘Virtual product development’ is a strategy for coordinating technology, processes and people to enhance the established product development process. It is a gradual process that efficiently builds up a product virtually. Thus any changes to be made in its design can be reflected into its physical properties, supply chain, distribution channel and ultimately into the customer view; without physically manufacturing the product.

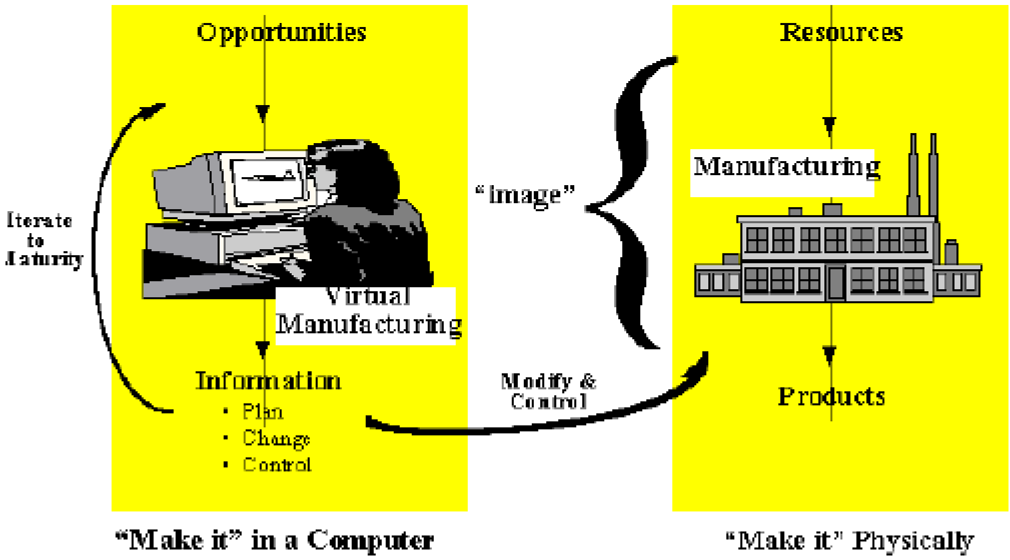
VPD encompasses a wide variety of software tools to cover a product from the conception to the final design and even manufacturing. This path consists of various processes to be carried out at manufacturing level, testing procedures and the final design which is modified automatically based on the test results. One of the major advantages of VPD is its computer brain capability, which can simulate various complex load conditions at a time. Non-linear load conditions are not always possible to create at the testing centre where the prototypes are being tested in conventional testing methods. These complex conditions, if accommodated in the testing, can yield more reliable product form.

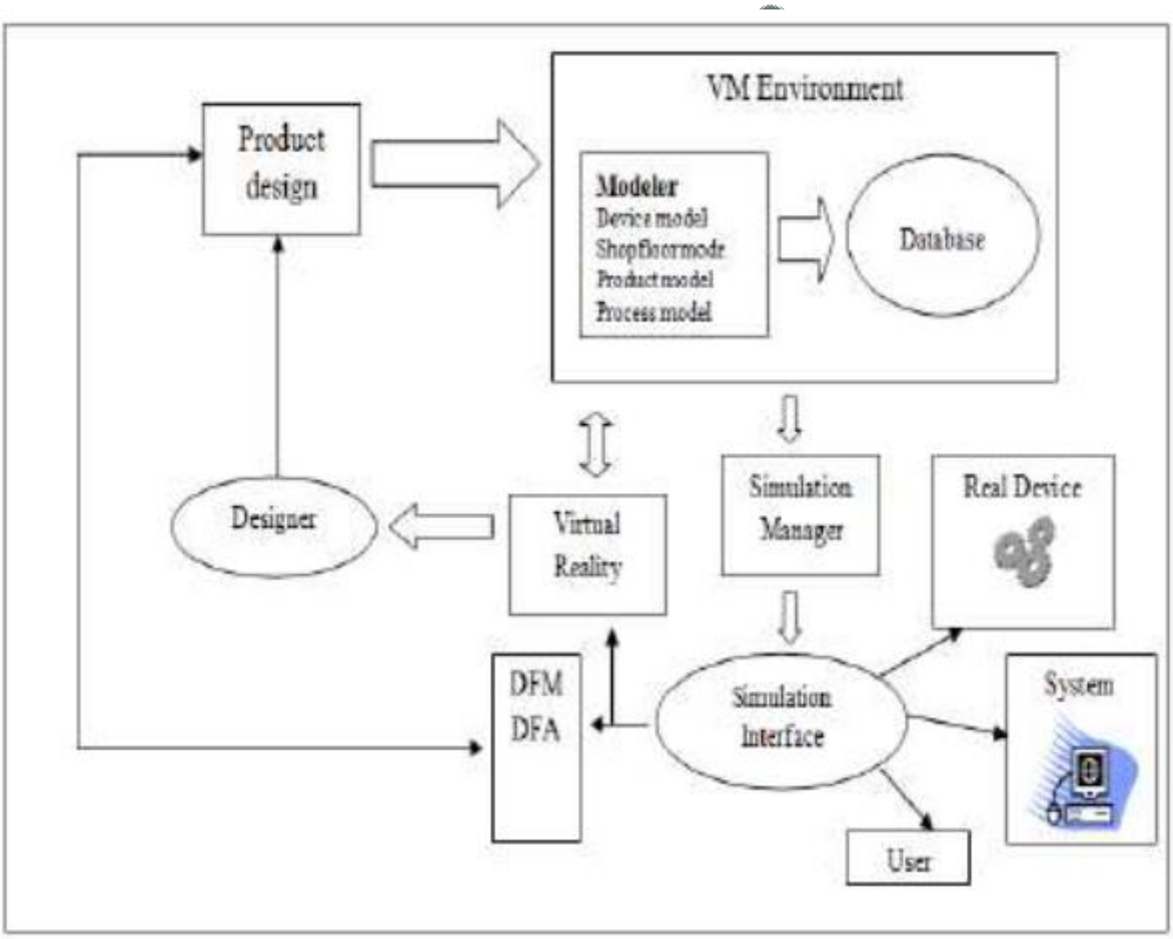
It is a new kind of manufacturing technology.

It is based on:

- **Simulation technology**
- **Virtual reality technology**
- **Information technology**
- Virtual Manufacturing system is a computer system which can generate the same information about manufacturing system’s structure, states and behaviors as we can observe in real manufacturing systems.

 VM is used in interactive simulation of various manufacturing process such as virtual prototyping, virtual machining, virtual inspection, virtual assembly and virtual operational system.



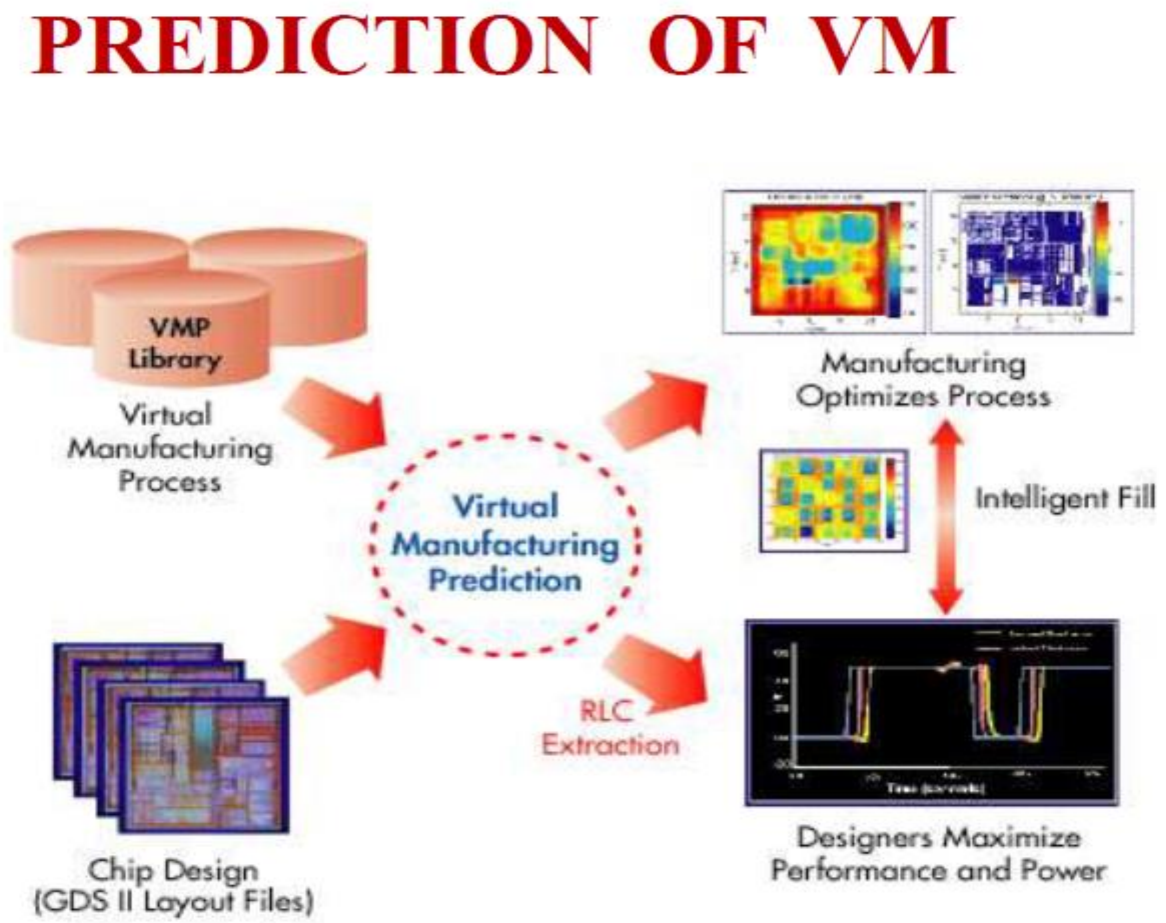



## 5.2 Task to Construct Virtual Environment

- Product model library
- Device model preparation
- Virtual shop floor model construction
- Virtual enterprise organization

**Need Of Vm Is?**

- Development of models
- Simulation of models
- Optimization of process
- Virtual prototyping
- Calculation of different parameters



## 5.3 CHARACTERISTICS

 Virtual manufacturing deals with the information and data of the product and manufacturing system.

 Virtual manufacturing is not true manufacturing, but in the manufacturing of computer and network system related with software.

 Virtual manufacturing processing results are digital products, rather than the real material products.

 Virtual manufacturing is a disperse system.

 The simulation of product design, processing and assembling process can be parallel operated.

## 5.4 CLASSIFICATION

- Classification based on types of products and process design.
- Classification based on type of system integration.
- Classification based on functional usage.

### 5.4.1 Classification based on types of product and process design

 Production-oriented Virtual Manufacturing

 Control-oriented Virtual Manufacturing

 Design-oriented Virtual Manufacturing

### 5.4.2 Classification based on type of system integration

 Real Physical System

 Real Information System

 Virtual Physical System

 Virtual Information System

### 5.4.3 Classification based on functional usage

 Virtual Prototyping

 Virtual Machining

 Virtual Inspection

 Virtual Assembly

 Virtual Operational Control

### 5.4.4 METHODS AND TOOLS USED IN VIRTUAL MANUFACTURING

- Manufacturing characterization
- Modeling and representation technologies
- Visualization, environment construction technologies
- Verification, validation and measurement
- Multi discipline optimization

### 5.4.5 EXISTING TOOLS FOR VM

**Design Tools**

- Computer Aided Engineering (CAE)
- 3-Dimensional Computer Aided Design (CAD) Models
- Design for Manufacturability & Assembly (DFMA)

**Production Tools**

- Computer Integrated Manufacturing (CIM)
- Advanced Modeling and Simulation
- Distributed Interactive Simulation (DIS)
- Integrated Product/Process
- Development (IPPD)
- Just in Time (JIT)
- Materials Requirement Planning (MRP),
- Manufacturing Resources Planning (MRP II)

**Quality Tools**

- Total Quality Management (TQM)
- Quality Function Deployment (QFD)

**Artificial Intelligence (AI) Tools**

- Expert Systems
- Neural Networks
- Fuzzy Logic,
- Object Oriented Technologies
- Autonomous Agents

**Management Tools**

- Quality Philosophies in Manufacturing
- Manufacturing Strategies
- Management Information Systems (MIS)

OVERVIEW OF SIMULATION TOOLS

| Level of Manufacturing | Simulation Type | Targets | Priority |
|---|---|---|---|
| Factory Shopfloor | ✓ Flow simulation<br>✓ Business process simulation | • Storage and logistics<br>• Production values<br>• Production planning and control | Low |
| Manufacturing Systems | ✓ Flow simulation | • Layout of the system<br>• Material flow<br>• System capacity<br>• Control plans<br>• Planning | Intermediate |
| Manufacturing machine tool | ✓ Flow simulation<br>✓ 3D kinematic simulation using commercial software | • Layout of specific cell<br>• Programming<br>• Testing | High |
| Components | ✓ Finite element analysis<br>✓ Multibody simulation | • Structural (Static and Thermal)<br>• Non Linear analysis<br>• Dynamic analysis | Complex |
| Manufacturing processes | ✓ Finite element analysis | • Cutting processes: surface properties, thermal effects, tool wear / life time, chip creation<br>• Metal forming processes: formfill, material flow, residual stress, cracks | Very complex |

### 5.4.6 FACTORS MAXIMIZED EFFECTIVENESS OFVM

- 3 D visualization
- Identical Man-Machine Interface
- Simulation
- Interface and monitoring

### 5.4.7 BENEFITS OF VIRTUAL MANUFACTURING

- Quality
- Shorter cycle time
- Producibility
- Flexibility
- Responsiveness
- Customer relations

### 5.4.8 DRAWBACKS

- Integration of simulation systems in planning and design tools
- Automatic generation of simulation models
- Distributed simulation, optimization and control
- Hybrid simulation
- Human-computer interfaces
- Virtual prototyping

### 5.4.9 APPLICATIONS

- Virtual Prototyping
- Maintenance.
- Virtual machine tools.
- Material and warehouse distribution systems study and development.
- VM for sheet metal processing.
- Virtual machining and inspection system
- Airport operations.
- Urban traffic operations.
- National economy study.
- Waging military battles.



### 5.5 Digital Mockup

Digital MockUp or DMU is a concept that allows the description of a product, usually in 3D, for its entire life cycle. Digital Mockup is enriched by all the activities that contribute to describing the product. The product design engineers, the manufacturing engineers, and the support engineers work together to create and manage the DMU. One of the objectives is to have an important knowledge of the future or the supported product to replace any physical prototypes with virtual ones, using 3D computer graphics techniques. As an extension it is also frequently referred to as Digital Prototyping or Virtual Prototyping. These two specific definitions refer to the production of a physical prototype, but they are part of the DMU concept. DMU allows engineers to design and configure complex products and validate their designs without ever needing to build a physical model.

Among the techniques and technologies which make this possible are:

- the use of light-weight 3D models with multiple levels of detail using lightweight data structures such as JT XVL and PDF allow engineers to visualize, analyze, and interact with large amounts of product data in real-time on standard desktop computers.
- direct interface to between Digital Mockups and PDM systems.
- active digital mockup technology that unites the ability to visualize the assembly mockup with the ability to measure, analyze, simulate, design and redesign.

### 5.6 Material Master Data Management (MMDM)

Material master data (often referred to simply as the “material master” or “item master”) contains descriptions of all materials that an enterprise procures, produces, and keeps in stock. It is the central repository of information on materials and contains descriptions of a variety of data elements including part number, description, technical specifications and stocking codes.

Material master is considered the core functionality for any ERP system used in distribution or manufacturing type functions. The integration of all material data in a single materials database eliminates the problem of data redundancy. This permits the data to be used by various departments/applications.



### 5.7 Data model

A **data model** is an abstract model that organizes elements of data and standardizes how they relate to one another and to the properties of real-world entities. For instance, a data model may specify that the data element representing a car be composed of a number of other elements which, in turn, represent the color and size of the car and define its owner.

The term **data model** can refer to two distinct but closely related concepts. Sometimes it refers to an abstract formalization of the objects and relationships found in a particular application domain: for example the customers, products, and orders found in a manufacturing organization. At other times it refers to the set of concepts used in defining such formalizations: for example concepts such as entities, attributes, relations, or tables. So the "data model" of a banking application may be defined using the entity-relationship "data model". This article uses the term in both senses.

A data model explicitly determines the structure of data. Data models are typically specified by a data specialist, data librarian, or a digital humanities scholar in a data modelling notation. These notations are often represented in graphical form.

A data model can sometimes be referred to as a data structure, especially in the context of programming languages. Data models are often complemented by function models, especially in the context of enterprise models.