LECTURE #2

Introduction to Computer Aided Engineering

Introduction

- Catagorisation of CAE
- Elements of CAE
- Role of Computer-aided tools
- Computers in the design process
- CAD ?
- CAM ?
- CAD/CAM ?
- CIM ?
- Concurrent engineering
- Design for X

What is Computer Aided Engineering

Computer aided engineering is the performance of engineering tasks and functions with the aid of a computer.

These tasks are still administrated and controlled by the engineer.

CAE is a well-estanlished field but it has been poorly formalized and very fragmented.

What is Computer Aided Engineering

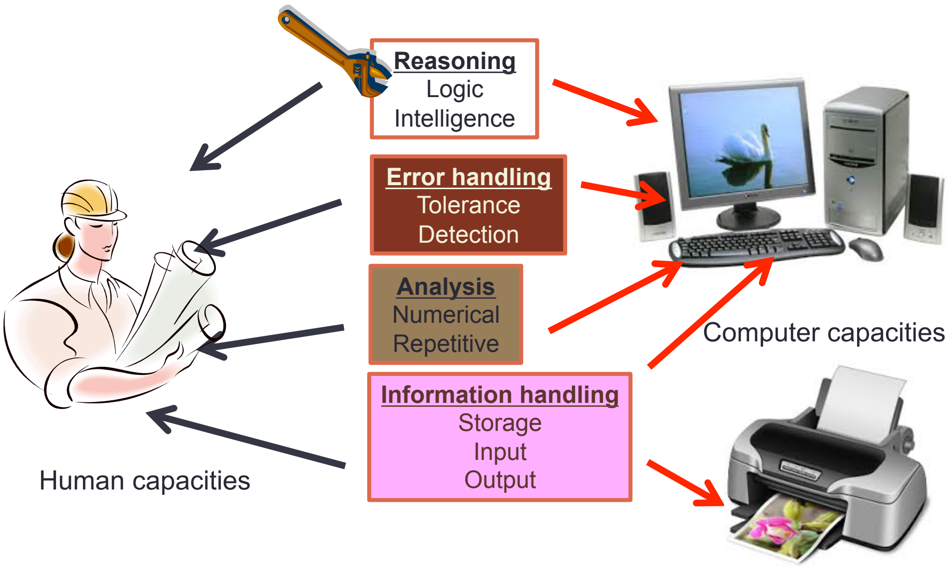
CAE covers the whole field of CAD & CAM

CAD involves computers in the design process

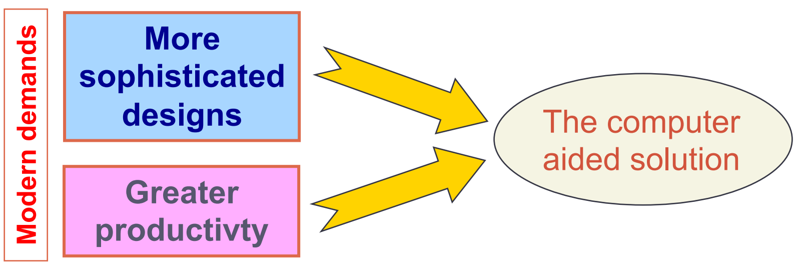
CAM deals with numerically controlled machine tools, automatic testing equipment and production control techniques.

CIM provides a link between design and manufacture

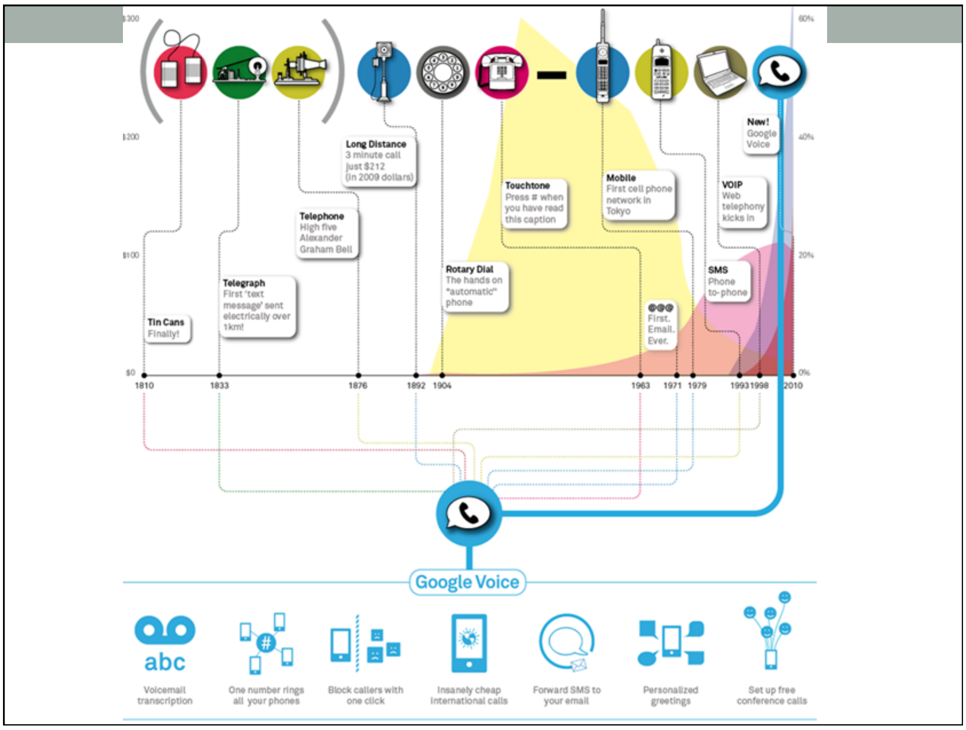
The computer & Engineer



The need for CAE



CAE techniques provide the means to cope with the demand for increased productivity of more sophisticated and reliable product design and manufacture.



PrimeiroPlano DIAGRAMA

Os tijolões estão de volta

Finos, leves e com telas exuberantes, os celulares voltaram a brigar pelo tamanho

Bruno Ferrari (texto), **Marco Vergotti** e **Rodrigo Fortes** (gráfico)

"GAROTAS DO MEU BRASIL VARONIL." O bordão é do personagem Zé Bonitinho, interpretado pelo humorista Jorge Loredo em diferentes programas de TV nas últimas décadas. Além das frases de efeito e de um figurino espalhafatoso, Zé Bonitinho carregava um enorme telefone entre seus acessórios. Era para dar um visual brega, fora de moda, numa época em que a moda eram os aparelhos menores e mais discretos. "Tijolão" era o apelido pejorativo para os aparelhos celulares dos anos 1990, que mal cabiam no bolso. Se fosse hoje, Loredo provavelmente teria de inventar outro acessório para fazer graça. Os celulares gigantes voltaram a fazer sucesso. Culpa das telas com resolução cada vez maior. Permitem assistir a vídeos, ver fotos, ler livros e revistas numa qualidade inédita. Ao mesmo tempo, a evolução tecnológica tornou os componentes – como baterias e processadores – menores e mais leves. Os celulares estão maiores, mas também mais leves e mais finos. Alguns modelos, como o Samsung Galaxy Note, lançado neste mês, são quase um tablet. Até onde eles vão crescer?

COMO ELES CRESCERAM
Pesos e medidas que ajudam a entender a evolução dos celulares

1 Dimensões
O tamanho dos celulares depende dos componentes, como o processador, a antena e a bateria. Com a evolução tecnológica, essas partes estão menores e mais eficientes

2 Tamanho da tela
Virou um dos principais atrativos dos celulares, com a chegada das telas de toque. A tecnologia de telas com LED permite maiores dimensões com menor consumo de bateria

3 Resolução
Quanto maior o número de pontos na tela, melhor a qualidade das imagens, além de cores mais vibrantes. Os aparelhos recentes têm telas com qualidade similar à de TVs full HD

4 Peso
Os celulares de hoje têm praticamente o mesmo tamanho de suas telas. O uso de materiais mais leves na estrutura, como compostos plásticos, manteve os aparelhos leves, mesmo os maiores

5 Peso / altura
Os consumidores aceitam aparelhos cada vez maiores porque eles não ficaram mais pesados. Repare que a proporção entre peso e altura do celular mudou pouco ao longo dos anos

6 Altura / espessura
Os celulares emagreceram. O primeiro deles tinha altura de 3,6 vezes a espessura. Hoje, o Motorola Razr é 18,5 vezes mais alto que sua espessura. É quase um cartão no bolso

Galaxy Note
Galaxy Nexus
iPhone 4S
TAMANHO REAL
As dimensões verdadeiras de alguns "tijolões" recentes

Foi o primeiro celular vendido comercialmente no mundo. A antena (não retrátil) era responsável por mais de um terço do tamanho do aparelho. Guardava até 30 números na memória e a bateria durava oito horas em espera. Custava US$ 4 mil na época, quase US$ 9 mil em valores atualizados

O Startac foi o marco dos celulares pequenos e finos. Era desejado e sinônimo de status. Custava caro se comparado aos aparelhos de hoje: cerca de US$ 1.000. Foi um dos aparelhos mais vendidos da história, com 60 milhões de unidades no mundo inteiro

Representa o auge dos tempos em que fabricantes brigavam para ter os celulares menores e mais leves. De tão pequeno, era difícil digitar no teclado. Fez sucesso entre os jovens

A Palm inventou os smarthphones quando juntou seus tablets de bolso com os celulares. O Treo 650 fez sucesso entre os executivos. Era gordinho, mas cabia no bolso do paletó. O tamanho conciliava o teclado QWERTY com a tela comandada por uma canetinha. Inspirou os BlackBerrys, mas foi suplantado pela tecnologia de toque do iPhone

Inventou um novo jeito de usar o telefone, com vários gestos dos dedos. A tela grande virou meio para exibir fotos, tocar vídeos, jogar games e até ler livros

Ele é proporcionalmente o mais pesado e o mais "cheinho" da nova geração de aparelhos. Há uma explicação. Foi o primeiro a incorporar uma câmera 3D (com duas lentes) que grava vídeos e faz fotos. A tela do celular exibe imagens em três dimensões sem a necessidade de óculos especiais

Recém-lançado no Brasil por R$ 2 mil, o Galaxy Note consegue ser fino, elegante e gigante ao mesmo tempo. É o sonho de consumo dos amantes das telonas. Ele vem com sistema Android e uma excelente câmera de 8 megapixels. Para os saudosistas da Palm, tem uma canetinha digital para anotações e desenho

	Motorola Dyna TAC 8000x	Motorola Microtac Elite	Motorola StarTac	Nokia 6120	Nokia 3310	Panasonic G51	Nokia 6600	Motorola Razr V3
	1983	1994	1996	1997	2000	2003	2003	2004
1	33 x 4,4 x 8,9 cm	15,3 x 5,8 x 2,2 cm	9,8 x 5,7 x 2,3 cm	13 x 4,7 x 2,8 cm	11,3 x 4,8 x 2,2 cm	8 x 4,3 x 1,8 cm	10,9 x 5,8 x 2,4 cm	9,8 x 5,3 x 1,3 cm
2	Menos de 1 polegada	Menos de 1 polegada	Menos de 1 polegada	2 polegadas	2 polegadas	1,3 polegada	2,1 polegadas	2,2 polegadas
3	*	*	*	240 x 320 pixels	84 x 84 pixels	128 x 96 pixels	176 x 208 pixels	176 x 220 pixels
4	785 gramas	113 gramas	112 gramas	137 gramas	133 gramas	74 gramas	122 gramas	95 gramas
5	23,7 gramas/cm	7,3 gramas/cm	11,4 gramas/cm	10,5 gramas/cm	11,7 gramas/cm	9,25 gramas/cm	11,1 gramas/cm	9,6 gramas/cm
6	3,6	6,9	4,2	4,6	5,1	4,4	4,5	7,5

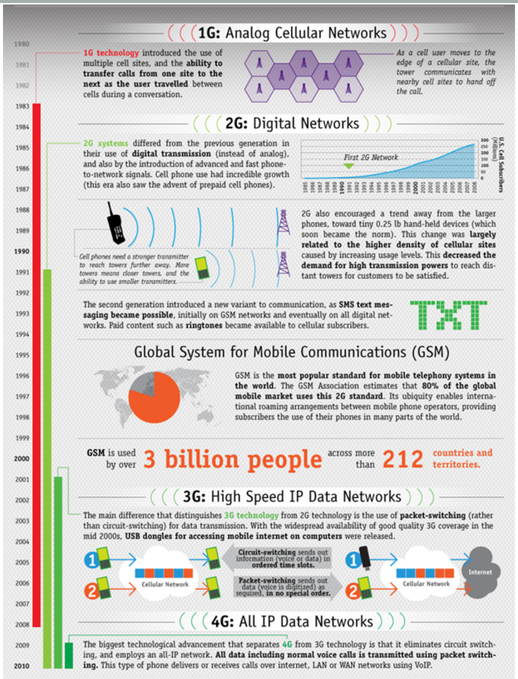
	Palm Treo 650	Nokia N95	Apple iPhone	BlackBerry 8800	LG Optimus 3D	Motorola Droid Razr	Samsung Galaxy Nexus	Samsung Galaxy Note
	2004	2006	2007	2007	2011	2011	2011	2011
1	11,3 x 5,9 x 2,3 cm	9,9 x 5,3 x 2,1 cm	11,5 x 6,1 x 1,1 cm	11,4 x 6,6 x 1,4 cm	12,8 x 6,8 x 1,1 cm	13 x 6,8 x 0,7 cm	13,5 x 6,7 x 0,9 cm	14,6 x 8,3 x 0,97 cm
2	2,4 polegadas	2,6 polegadas	3,5 polegadas	2,5 polegadas	4,3 polegadas	4,3 polegadas	4,6 polegadas	5,3 polegadas
3	320 x 320 pixels	240 x 320 pixels	320 x 480 pixels	320 x 240 pixels	480 x 800 pixels	540 x 960 pixels	720 x 1.280 pixels	800 x 1.280 pixels
4	178 gramas	120 gramas	135 gramas	134 gramas	168 gramas	127 gramas	135 gramas	178 gramas
5	15,5 gramas/cm	12,1 gramas/cm	11,7 gramas/cm	11,7 gramas/cm	13,1 gramas/cm	9,7 gramas/cm	10 gramas/cm	12,1 gramas/cm
6	4,9	4,7	10,4	8,14	11,6	18,5	15,0	15,0

40 > ÉPOCA, 12 de dezembro de 2011

Fotos: divulgação (15) e Newscom

* Nos primeiros modelos, a resolução das telas era medida por números de caracteres, e não por pixel, como hoje

12 de dezembro de 2011, ÉPOCA > 41



4 Cell Phone Generations Compared

	Standards	Technology	SMS	Voice Switching	Data Switching	Data Rates
1G	AMPS, TACS	Analog	No	Circuit	Circuit	N/A
2G	GSM, CDMA, EDGE, GPRS	Digital	Yes	Circuit	Circuit	236.8 kbps
3G	UTMS, CDMA2000, HSPDA, EVDO	Digital	Yes	Circuit	Packet	384 kbps
4G	LTE Advanced, IEEE 802.16 (WiMax)	Digital	Yes	Packet	Packet	up to 1 Gbps

The Categorization of CAE

The mechanical / manufacturing engineers will use a variety of activities.

There is a computer assisted means for all of these:

design	numerical methods
analyse techniques	organization planning
manufacturing techniques	control

Int to CAE

In CAE, the data can flow electronically between the departments and the whole operations can be monitored and controlled.

Computer extends the designers' capabilities :

- Organizing & handling time consuming operations
- Repetitive operations
- Analyse complex problems

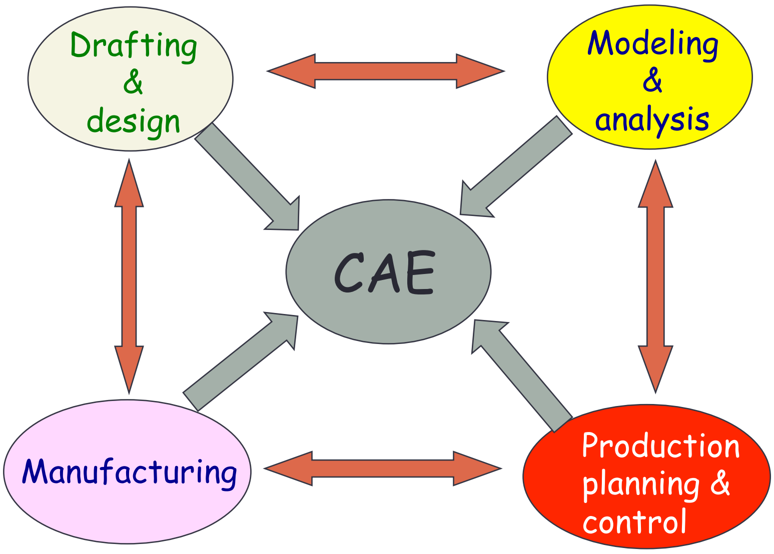
Impact of CAE on design

CAE is impacting engineering design.

The first CAE impact on detail design has occured in draughting (changing, redrawing, storing....).

In product line engineering decisions required. It requires standard engineering calculations, detail drawing, bill of materials (BOM).

The elements of CAE



Elements of CAE

COMPUTER AIDED ENGINEERING

Draughting and Design

CAD computer aided design
CADD draughting & design
DFA design for assembly/automation
CADCAM link to CAM

Modelling & Analysis

FEA finite element analysis
FDA finite diffennce analysis
mechanism design
contiouous simulation
discrete event simulation
dynamic analysis

Manufacture

CAM computer aided manufacturing
CNC computer numerical control
DNC direct/distributed numerical control
PLC programmable logic control
CMM coordinate measuring machines
FAS flexible assembly system
FMS flexible manufacturing system

Production planning & control

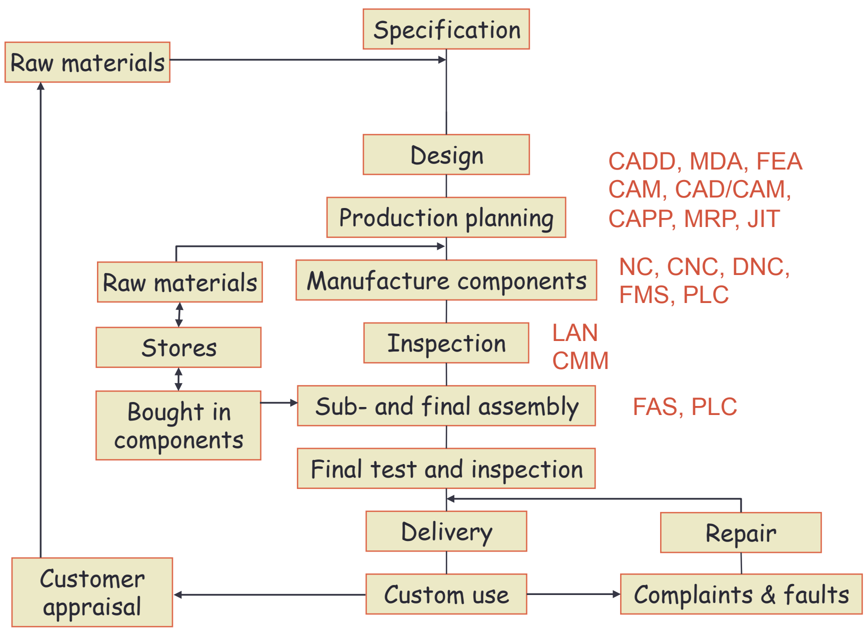
CAPP computer aided process planning
MRP material requirements planning
BOM bill of materials
JIT just-in-time
Production planning & control
Scheduling
Quality control

Int to CAE

There is overlaps and can not be isolated. They depend on departments. The trens is to adapt concurrent engineering.

The link between the area draughting and design, modeling and analysis is very strong.

CAE in the product development process



Terms in CAE

CAD	computer-aided design
CADD	computer-aided design & drafting
CAM	computer-aided manufacturing
CAPP	computer aided process planning
CIM	computer integrated manufacturing
CMM	coordinate measuring machine
DNC	direct numerical control
FAS	flexible assembly systems
FMS	flexible manufacturing systems
JIT	just-in-time
LAN	local area network
MDA	mechanism design analysis
MRP	materials requirement planning
PLC	programmable logic controller

Totaly Automated Factory

If all the software and hardware tools are applied to every possible stage and are linked together with CIM (computer integrated manufacturing) environment.

It is rare ! Needs more human intervention.

Specification stage (Conceptual design)

Computer application is limited with word processing or desktop publishing.

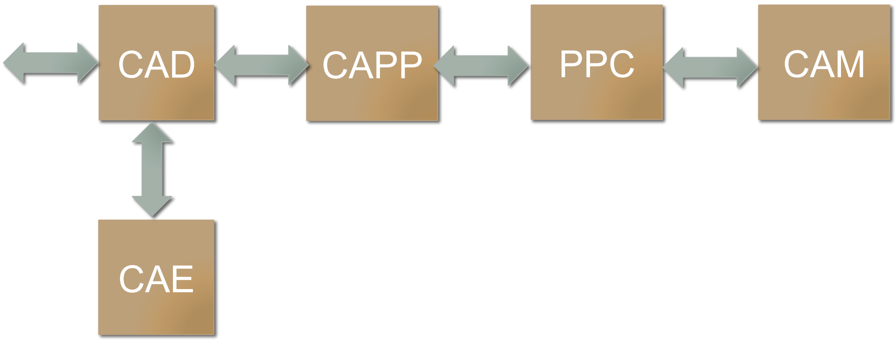
Spreadsheet program are useful because of their ability to quickly make multiple calculations without requiring the user to reenter all of the data.

Limited computer applications

Design stage

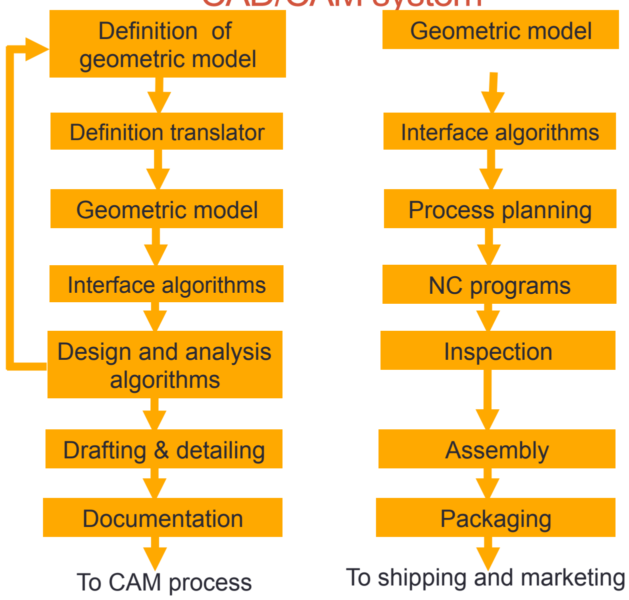
- Manufacture needs to be planned
- The methods and processes used for manufacturing
- The scheduling of production
- The acquisition of raw materials & bought-in components.
- The control of quality

Computers in manufacturing



The ability to construct accurate, easily modified models is helping make manufacturers more competitive.

Implementation of a typical CAD and CAM process on a CAD/CAM system



CAD

Geometric Modeling
Engineering Analysis
Design Review and Evaluation
Automated drafting

Computers in CAD

Some of the tools provided in a CAD environment are,

- Innovative and conceptual design
- Qualitative design analysis
- Structuring of part (eg. assemblies)
- Knowledge based/intelligent design tools
- Engineering design information (standards lookup, or electronic catalogues)
- Optimization
- Design interfaces, and tools

Some applications are well suited to 2D CAD systems,

- PCBs (Printed Circuit Board Design)
- ICs (Integrated Circuit Design)
- Mapping (road maps, topographical maps)

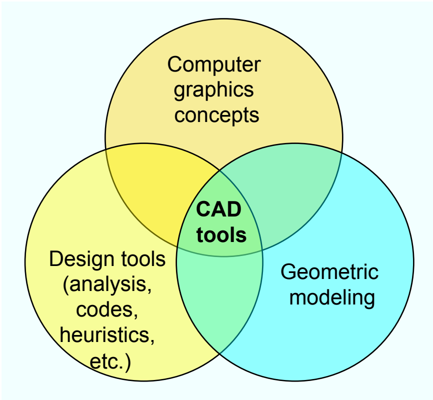
Advantages of CAD systems

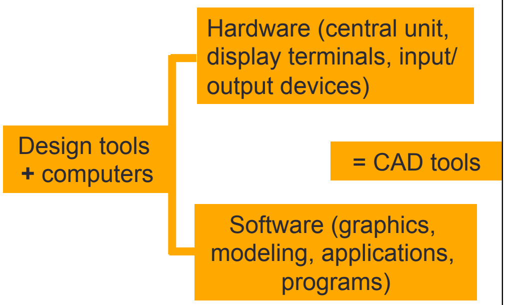
- Visualization
- Minimizes design errors
- Graphical display of hard to visualize information
- Standardized drawings, and documents
- Faster lead time
- Customer perception is improved
- Productivity improvement over time
- Developing alternate concepts
- Evaluation of alternate concepts
- Analytical investigation of parts
- Experimental investigation
- Detailed drawings and specifications
- Preliminary 'construction' of design prototype
- Easy bridge to prototype construction
- Easy to change designs
- Optimization

CAD tools to support the design process

Design Phase	Required CAD tools
Design conceptualization	Geometric modeling techniques; graphics aids, manipulations, and visualization
Design modeling and simulation	Same as above; animation; assemblies; special modeling packages
Design analysis	Analysis packages; customized programs and packages
Design optimization	Customized applications; structural optimization
Design evaluation	Dimensioning; tolerances; bill of materials; NC
Design communication and documentation	Drafting and detailing; shaded images

Definition of CAD tools based on their constituents





Definition of CAD tools based on their implementation in a design environment

CAM

Classification

Planning

- Cost Estimating
- CAPP
- NC Part Programming
- Machinability Data Systems
- Computerized Work Standards
- Materials Requirement Planning
- Capacity Planning
- Production & Inventory Planning

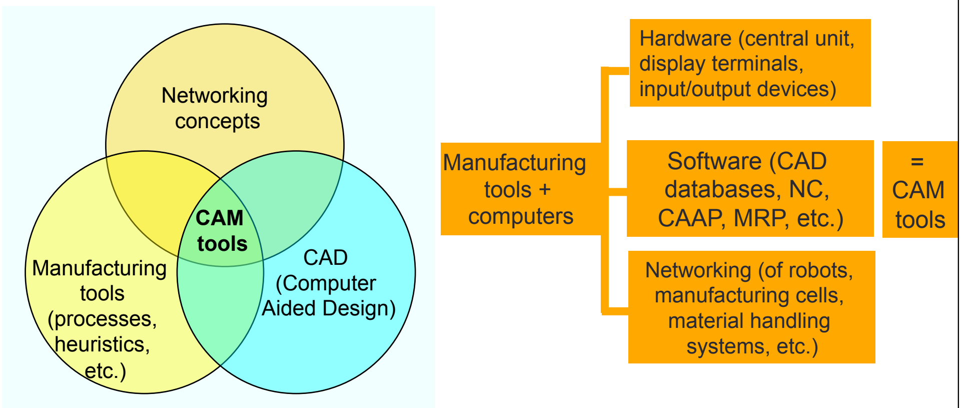
Control

- Process Monitoring
- Process Control
- Shop Floor Control
- Cost Control
- Computer Aided Quality Control

CAM tools required to support the manufacturing process

Manufacturing Phase	Required CAM tools
Process planning	CAPP techniques; cost analysis, material and tooling specification
Part programming	NC programming
Inspection	Inspection software
Assembly	Robotics simulation and programming

Definition of CAM tools based on their constituents



Definition of CAM tools based on their implementation in a design environment

What is CAD/CAM? . . .

Using computers for design and manufacturing.

Computerize the easier tasks, which are tedious and mistake prone when done manually.

In **CAD**, design product geometries, do analysis, and produce final documentation.

In **CAM**, parts are planned for manufacturing (e.g. generating NC code), and then manufactured with the aid of computers.

What is CAD/CAM? . . .

CAD/CAM tends to provide solutions to existing problems.

For example, analysis of a part under stress is much easier to do with FEM, than by equations, or by building prototypes.

CAD/CAM systems are easy to mix with humans.
This technology is proven, and has been a success for many companies.

What is CAD/CAM? . . .

There is no 'ONE WAY' of describing CAD/CAM.

It is a collection of technologies which can be run independently, or connected.

If connected they are commonly referred to as CIM.

What is the difference between CAD, CAM & CIM . . .

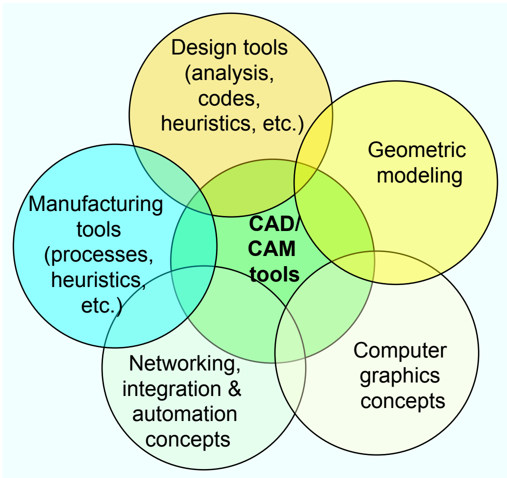
CAD/CAM involves the use of computers to make Design and Manufacturing more profitable.

Parts of CIM use CAD/CAM techniques and products to try and make the factory fully connected using computers.

What is the difference between CAD, CAM & CIM . . .

- The essential difference is **CAD/CAM** provides the tools, CIM is the philosophy which is used when organizing the computers, programs, etc. and all the information that flows between them.
- Another way to think of CIM is that it allows the structure of an organization to be entered into the computers.
- CIM focuses on connecting the various CAD/CAM modules.

Definition of CAD/CAM tools based on their constituents



Computer Integrated Manufacturing (CIM)

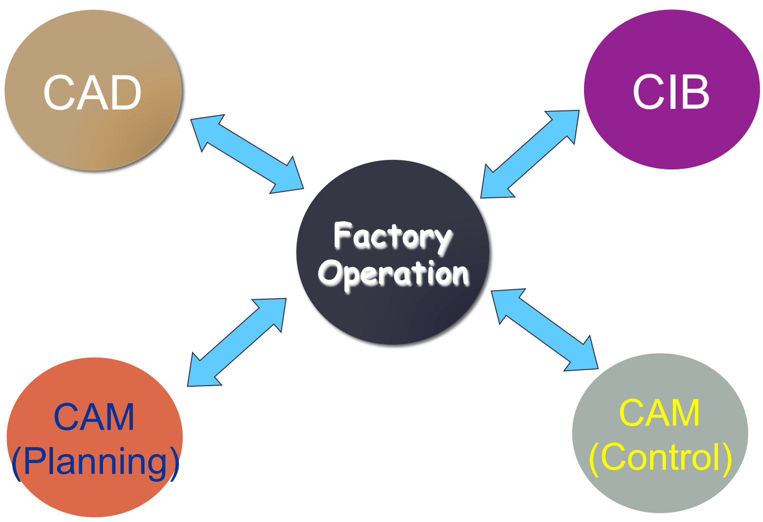
- CIM is a concept for integrating all components involved in the production of an item.
- The engineering functions including NC,CNC,DNC,CAD/CAM, GT,CAPP,MRP,AGVs are integrated with business activities
- Integration media is through communication networks using LAN/WAN/INTERNET technology

Computer Integrated Manufacturing (CIM)

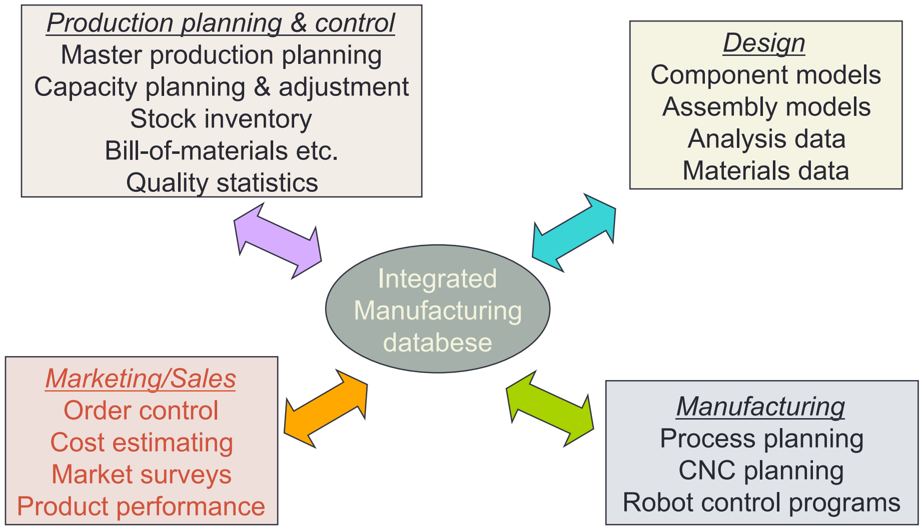
The product cycle includes

- idea generation
- product design
- procurement
- process planning
- product manufacture
- quality control
- packaging/shipping
- after sales service

Scope of CAD/CAM & CIM



Integrated Manufacturing Database



CONCURRENT ENGINEERING

Concurrent Engineering

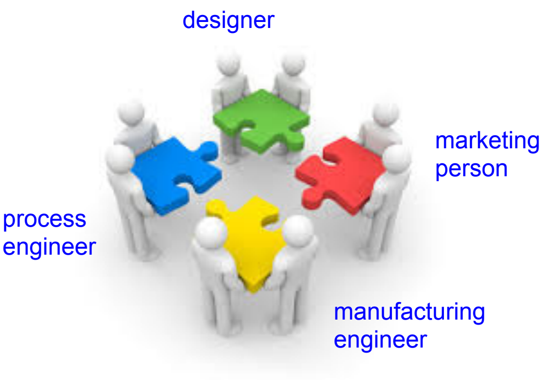
It is greatly facilitated by the use of CAE.

Alternative to over the wall engineering.
(Sequential engineering)

Parallel engineering.

Concurrent Engineering

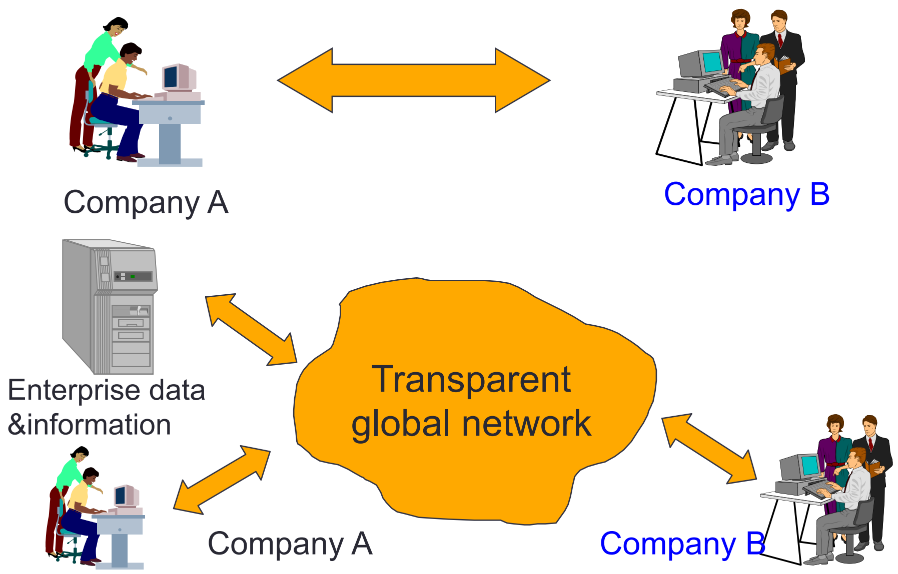
For maximum productivty a concurrent, parallel or simultaneous engineering approach should be adopted. This approach requires that the design process, and hence the design team.

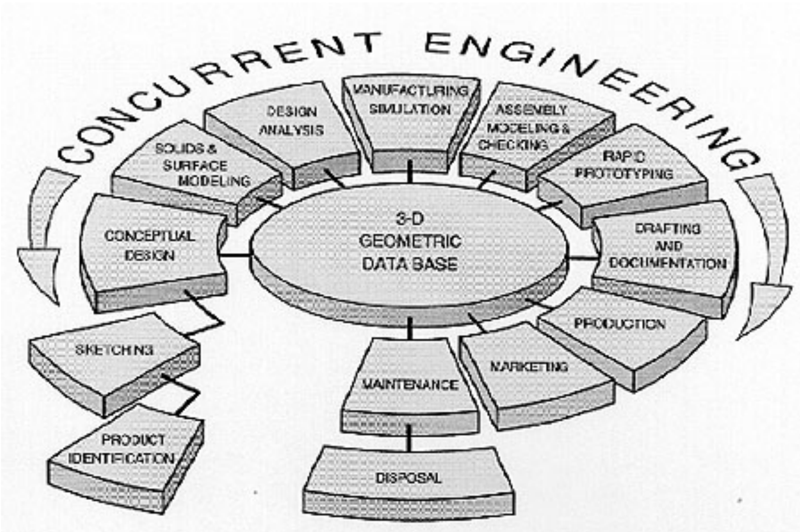


Concurrent Engineering

- ... 21st Century's response to competive conditions of the world market.
- CE refers to the process of considering simultaneously the requirements of assembly and manufacturing with design erequirements i order to reduce unit cost of production, improve quality and reduce total lead time.
- CE is managing mutual dependences of desing, manufacturing, distribution, support and service
- CE's aim is to minimize life-cycle cost, maximize customer satisfaction, maximize flexibilituy, minimize lead time from conception to delivery to the customer.

Geographically Distributed Teams





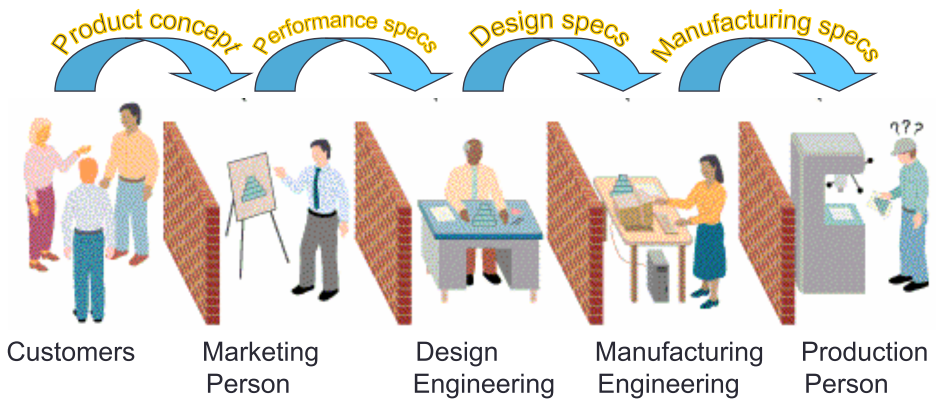
Sequential design

Each department has its own responsibility

When the task designated to that department is complete, the results are thrown **over the wall** to the next department.

Breaking Down Barriers

Sequential design : Walls between functional areas



Breaking Down Barriers

Concurrent design : Walls broken down

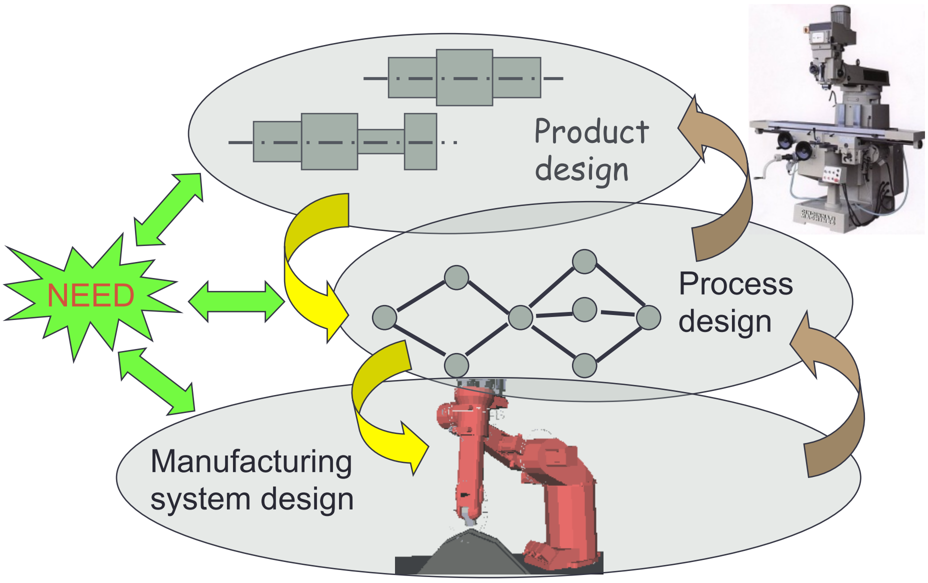
This over the wall approach to engineering has been common practice until quite recently;

The trend, is to adopt a concurrent engineering strategy to design and development where product idea are realized by a team made up of members of many departments.

Concurrent Engineering

- Simultaneous decision making by design teams
- Integrates product design & process planning
- Details of design more decentralized
- Needs careful scheduling - tasks done in parallel

Concurrent Approach



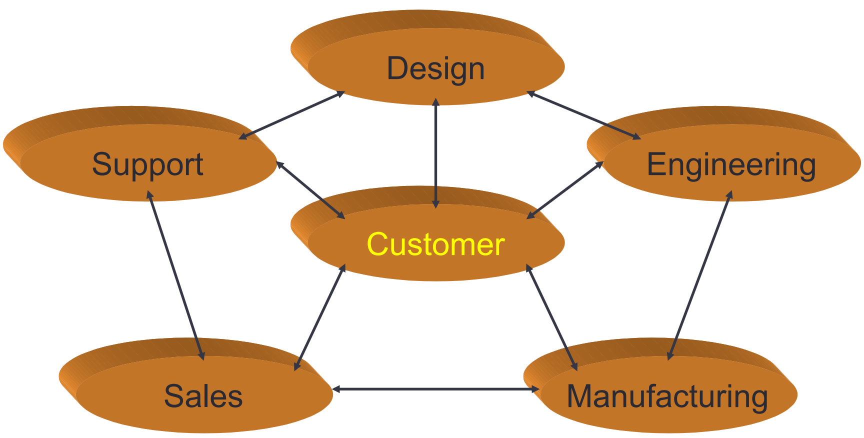
Concurrent Engineering

being used to transmit

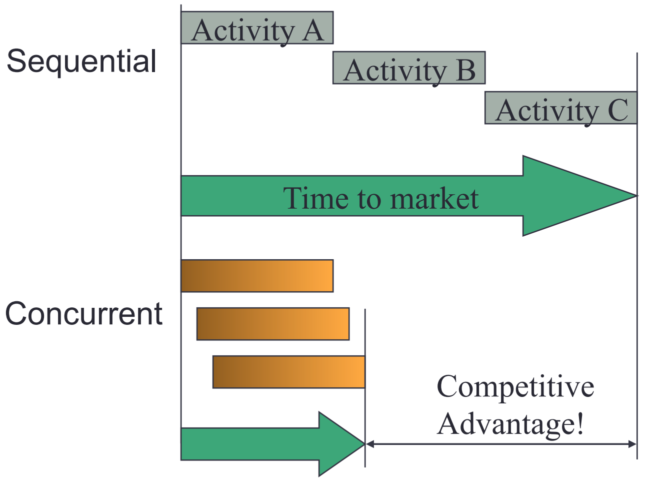
- 3-D solid models to tool designers,
- part vendors
- numerical control programmers for manufacturing development

via internet.

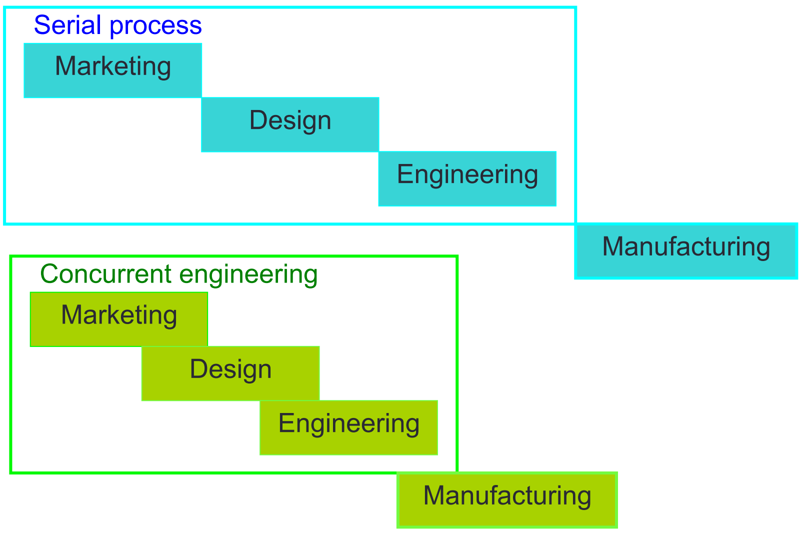
Concurrent Product Development



Sequential vs. Concurrent Product Development



Sequential vs. Concurrent Product Development



Conventional Collaboration

- Communication

  face-to-face discussion, memos, telephone, whiteboard, bulletin board, wall charts, etc.
- Collaboration

  meetings, co-located workgroup
- Knowledge management

  notebooks, binders, printed reports, photocopies, drawings, forms, data files

Virtual Collaboration

- Communication

  fax, telephone, mail

  email, discussion groups, shared whiteboard, videoconferencing
- Collaboration

  application sharing, shared network workspace (files in shared directories)
- Knowledge management

  Product data management system, document management system, distributed databases

Concurrent Engineering

It gives rise to new approaches to product development.

It enhances the effectiveness of existing productivity tools and these include

design for the market,

design for manufacture DFM

design for assembly DFA.

DFX

Design for X

Design for X

A growing emphasis on Concurrent Engineering, as it involves cross-functional teams, parallel design and vendor partnering etc.

A successful design must satisfy

- requirements
- functionality,
- appearance, and cost
- durability and reliability

Design for X

DFA	*Design For Assembly*
DFM	*Design For Manufacturability*
DFD	*Design For Disassembly*
DFI	*Design For Install ability*
DFM	*Design For Maintainability*
DFML	*Design For Material Logistics*
DFP	*Design For Portability (Software)*
DFQ	*Design For Quality*
DFR	*Design For Redesign*
DFR	*Design For Reliability*
DFR	*Design For Reuse*
DFS	*Design For Safety*
DFS	*Design For Simplicity*
DFS	*Design For Speed*
DFT	*Design For Test*
DFE	*Design For Environment*
DFESD	*Design For Electrostatic Discharge*
DFEMC	*Design For Electro-Magnetic Compatibility*

Design for Market

responsible for the marketing of the product are involved very early on in the design process and continue to be involved throughout the evolution of the design and manufacture.

involves the customer in design decisions:

physical models or
impressions of the design proposals.

Design for Manufacturing

Involvement of the manufacturing and production planning & control departments provides a valuable contribution to the manufacturability of a design.

DFM is the application of certain rules to the design of components that ensure cost-effective manufacture.

Design for Manufacturing

The basic objectives of DFMt

to assure that the product can be maintained throughout its useful life-cycle at reasonable expense without any difficulty

Design for Manufacturing

main concepts

reliability of systems

defined as the probability of failure free system or equipment operation during a prescribed time period and under specified conditions

maintainabilility

defined as the probability that a failed system can be repaired in a spesific interval of downtime

Design For Assembly

Consider how components are fitted together to form a subassembly or assembly.

Much of these considerations will affect component design as well as that of the overall product.

Design for Assembly

- systematic method
- analyzes product designs
  - to improve assembly easy
  - to reduce assembly time.
- a central element of DFM

Design for Assembly

Well established technique for cost reduction at the design-manufacture interface

defined as a process for improving product design for easy and low-cost assembly, focusing on functionality and on assemblability concurrently.

Design for Assembly

The aim

help the designer to produce an efficient and economic design, simplify the product

Design for Assembly

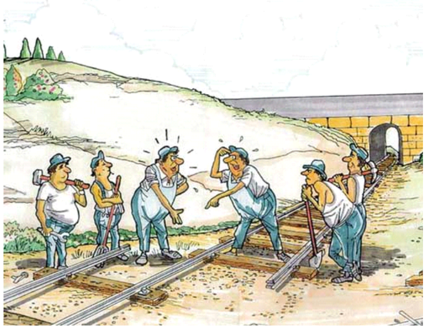
Implementation of DFA at the early **conceptual stage of design** has led to enormous benefits :

- simplification of products,
- lower assembly
- manufacturing costs,
- reduced overheads,
- improved quality
- reduced time to market.

Design for Assembly

broadened to include consideration of the difficulty of manufacture of the individual parts to be assembled.

providing the necessary basis for **teamwork** and simultaneous engineering.



Design for Assembly

The application of DFA guides the designer towards a product with an optimum number of parts

requires simple, cost-effective assembly operations and the most appropriate manufacturing processes and materials for its components.

include improved quality and reliability, and a reduction in production equipment and part inventory.

Quantitative evaluation methods

- Boothroyd-Dewhurst method,
- the Hitachi Assemblability evaluation method,
- the Lucas DFA method
- IPA Stuttgart method

Boothroyd-Dewhurst Method

- to determine the suitable assembly method,
- to reduce the number of each part be assembled,
- to get the handling and insertion processes easily

based on a system of penalties for the particular activity, including

part's handling,

part's insertion

using these penalties a quantitative judgement options

Boothroyd-Dewhurst Method

based on three principles:

(a) relying on an existing design which is iteratively evaluated and improved.

(b) the application of criteria to each part to determine if it should be separate from all other parts,

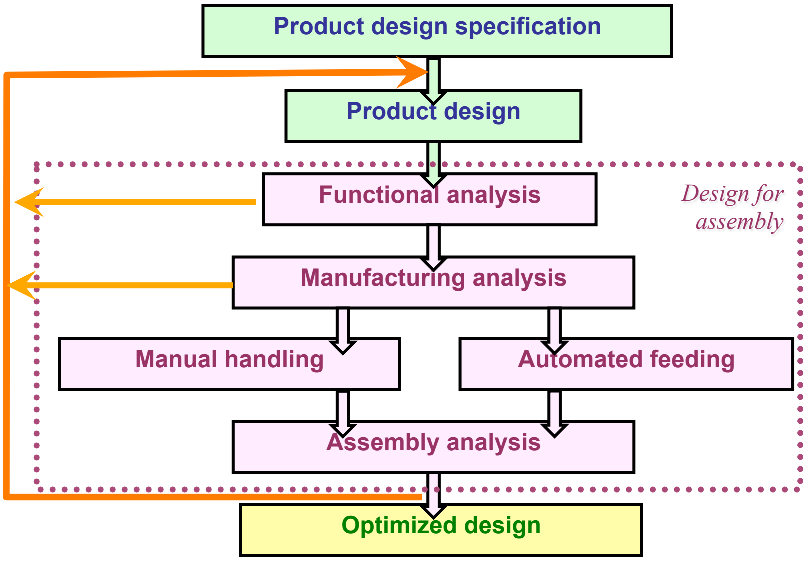
(c) estimation of the handling and assembly costs for each part using the appropriate assembly process

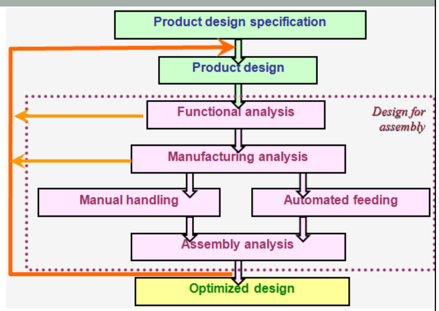
Boothroyd-Dewhurst Method

the process follows these steps:

- ❖Select an assembly method for each part
- ❖Analyze the parts for the given assembly methods
- ❖Refine the design in response to shortcomings identify by the analysis
- ❖Loop to step 2 until the analysis yields a sufficient design

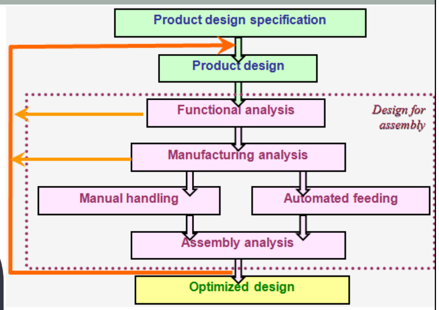
Flowchart of DFA





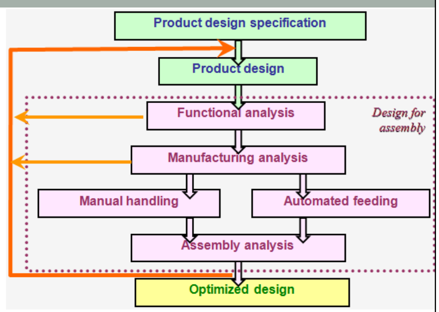
<u>FA</u> facilitates part count reduction by evaluation of each component in order to determine.

<u>FA</u> is essential for the performance of the product.



Individual components are assessed in terms of

- *their relative motion,*
- *material type*
- *the need for removal for replacement / repair*



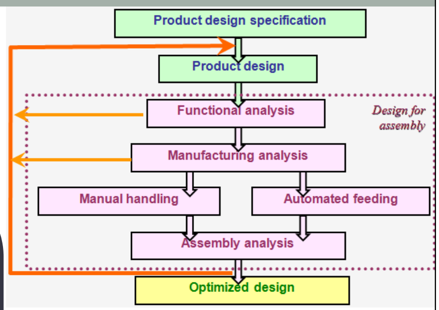
__Manufacturing Analysis__ determines the relative cost of producing each component based on the manufacturing processes used.

determined using a basic processing

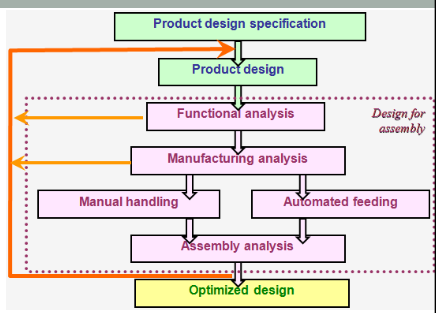
cost per annum (Pc) for an ideal design

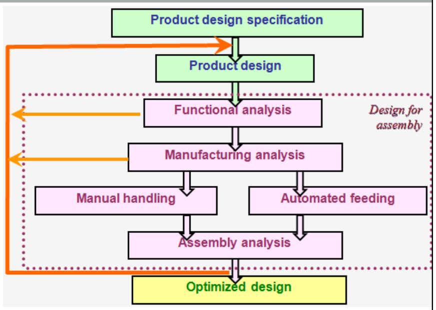
a design-dependent relative cost (Rc)

the cost of the material used (Mc).



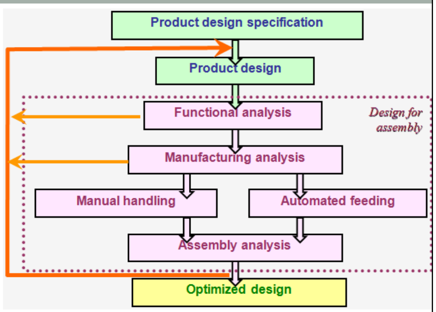
The Handling Analysis evaluates the suitability of a component for <u>manual handling</u> and <u>automated feeding</u> to the point of assembly.





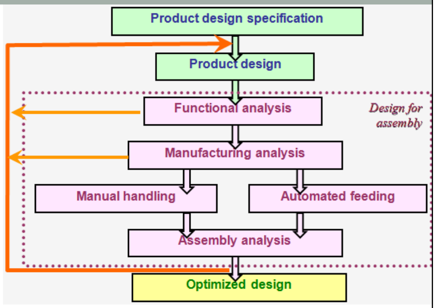
The evaluation :

- component shape
- characteristics,
- size,
- weight,
- orientation,
- mechanical properties.



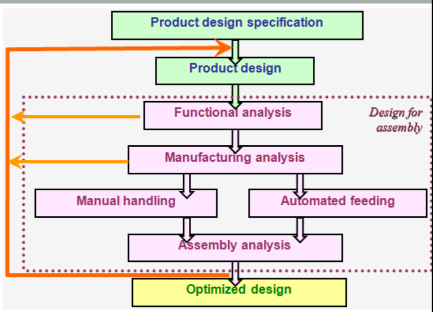
Careful selection

- leads to improvements in safety
- reduces the likelihood of component damage / incorrect insertions.
- reduces capital spend on equipment
- improves assembly times.



Assembly Analysis is used

- to highlight problems & inefficient operations associated with the build sequence & component interfaces,
- to identify the tooling requirements of the design



Assembly Analysis scores the difficulty associated with gripping each component

inserting it into the assembly for both manual & automated operations.

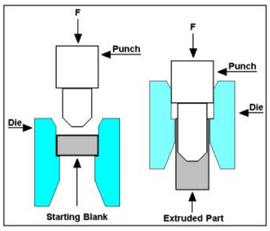
Suitability for part function

DFA

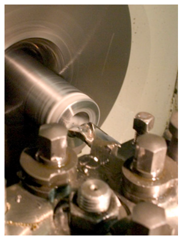
Quite often a particular component is manufactured in a certain way because a particular process is there rather than it being the most appropriate.

A component may be more cheaply produced


forming



İmpact extrusion


machining

Suitability for manufacturing process

DFA

The process planning of the component affects the design rather than the design influencing the process used for its manufacture.

Therefore a component' s geometry and appearance and the way it is to be manufactured are arrived at more or less simultaneously.

Variety control

DFA

Minimize the range of parts for a company's product range as well as reducing the number of different parts within any one product.

standardizing on one type of component

Standardization

DFA

This is an aspect of variety control which is also discussed below as being a crucial factor for a design for assembly strategy.

No company is so diverse in its product range that it can not carry out some degree of standardization of component parts.

Design for Manufacture & Assembly (DFMA)

Processes or procedures for integration of design and manufacture, with the goals of reducing manufacturing costs and improving product quality are termed as DFM. Associated with this for assembly is DFA.

DFM Guidelines

- Minimizing total number of parts
- Standardize components
- Use common parts across product lines
- Design parts to be multi-functional
- Design parts for ease of fabrication
- Avoid too tight tolerances
- Avoid secondary operations
- Utilize the special characteristics of processes

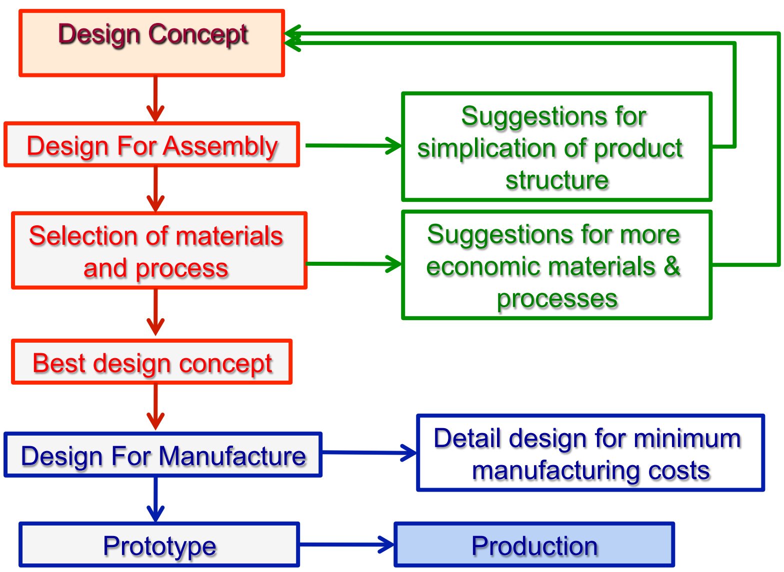
Assembly process consist of two parts

- *Handling*
- *Manual*
- *Automated*
- *Robotic*
- *Insertion*

DFA Guidelines

- Minimizing total number of parts
- Minimizing assembly surfaces
- Avoid separate fasteners
- Minimize assembly direction
- Maximize compliance in assembly
- Minimize handling in assembly

Integrated structure of DFA and DFM



Design for Automated Assembly

Many of the principles which can be applied to an assembly and which make it easier to put together by automated process.

Here are some of the important issues:

- Insertion direction and geometry
- Layered or sandwich construction
- Tangle free components
- Easy fastening

Insertion direction and geometry

DFAA

Insertion of components from the side requires more complex programming and specialized equipment.

Most standard pick and place devices (SCARA or Cartesian robots) can only effect vertical insertion.

Layered or sandwich construction

DFAA

Orientating a partly build product at various stages throughout its assembly can be an unnecessary and costly task.

Adopting a layered or sandwich type construction of a product it can remain in one orientation.

Tangle free components

DFAA

Springs and other components prone to tangling can be modified to partially or even totally eliminates the problem.

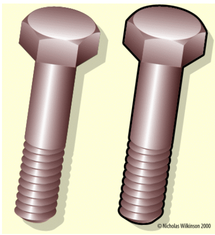
ease the orientation and presentation of such components to the assembly process and in a manual situation the operator is not spending a large proportion of time untangling small items

Easy fastening

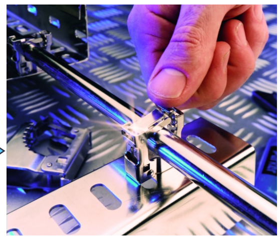
DFAA

As evaluation of the fastening together of components may also yield benefits.

Some fastenings are difficult to undo for maintenance and quite often result in the case being rendered useless.



screws



snap-together type

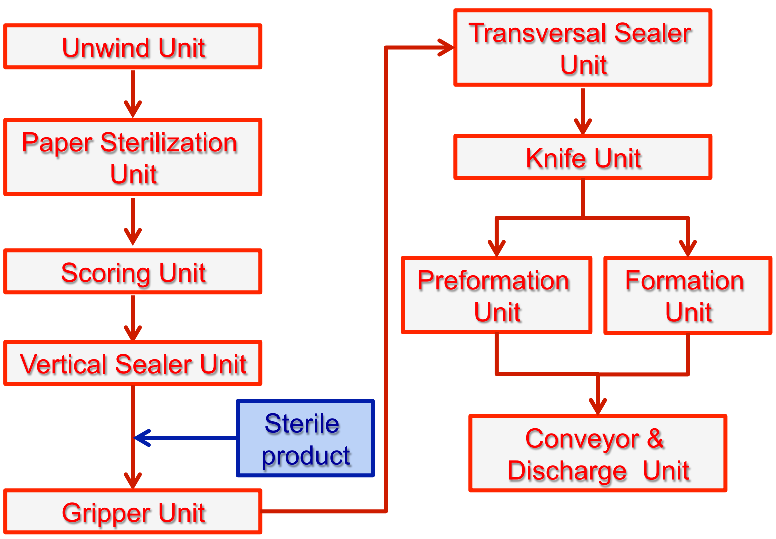
A CASE STUDY: PACKAGING

DESIGN FOR ASSEMBLY & MAINTAINABILITY IN COMPUTER AIDED ENGINEERING

Case Study : Packaging

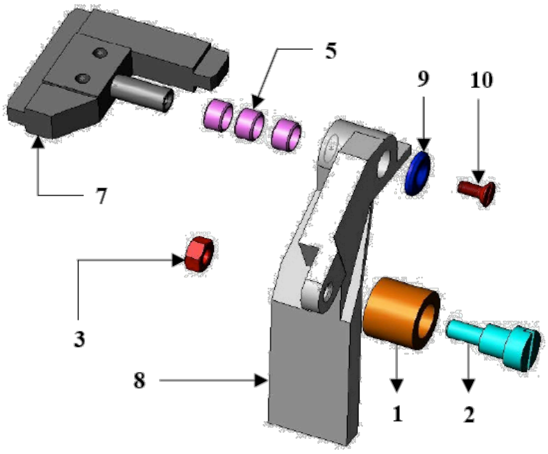
Fruit juice packages are fiiled with pasteurized product and packaged under sterilized and closed conditions using roll shaped packaging board which is got by board suppliers.

Flowchart of filling & packaging system



Current design

pushed to exit of machine with help of expeller subassembly group after finishing filling and formation processes.

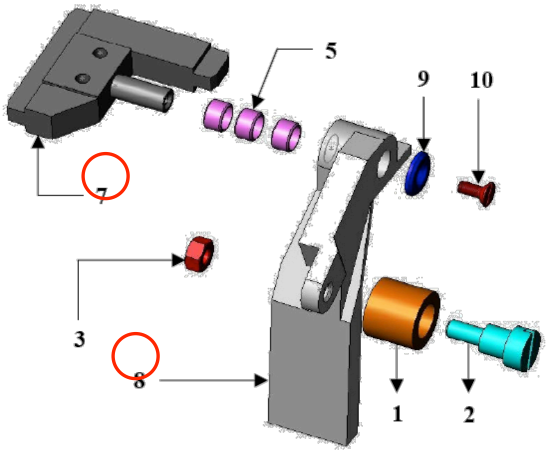


This group follows a certain route with a guide chain

Current design

⑦ the main support of subassembly and the holes which stay up to this part is for chain connection links.

⑧ fixed onto ⑦ with screw by guidance of welded pin.



As time passed, the length of chain gets longer and loses its tightness.

DFA evaluation

Part Number	Part Name	Part Repetition	Manuel Handlig Code	Manuel Handlig Time (s)	Manuel Insertion Code	Manuel Insertion Time (s)	Total Assembly Time (s)	Manuel Assembly Cost	Minimum Part Number
1	Guide Part	1	10	1,50	06	5,50	7,00	0,02	1
2	Bolt	1	10	1,50	38	6,00	7,50	0,02	0
3	M6 Nut	1	01	1,43	38	6,00	7,43	0,02	0
4	Orientation	1	-	-	98	9,00	9,00	0,03	-
5	Bushing	3	01	1,43	31	5,00	19,29	0,06	1
6	Orientation	1	-	-	98	9,00	9,00	0,03	-
7	Main Support	1	10	1,50	31	5,00	6,50	0,02	1
8	Package Expeller	1	10	1,50	16	8,00	9,50	0,03	1
9	Washer	1	11	1,8	06	5,50	7,30	0,02	0
10	M4 Bolt	1	16	2,57	39	8,00	10,57	0,03	0
TOTAL							93,09	0,28	4

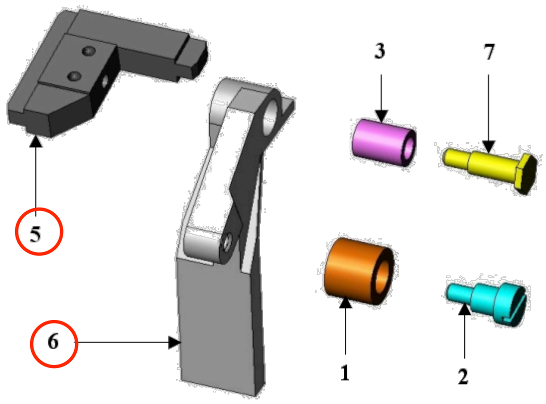
DFA Index = 4 x 3 / 93,09 = **% 12,9**

New design

The welded pin divided from the main support

Multi pieces bushings' design changed

unnecessary fastening parts *(nut, washer)* eliminated



DFA evaluation

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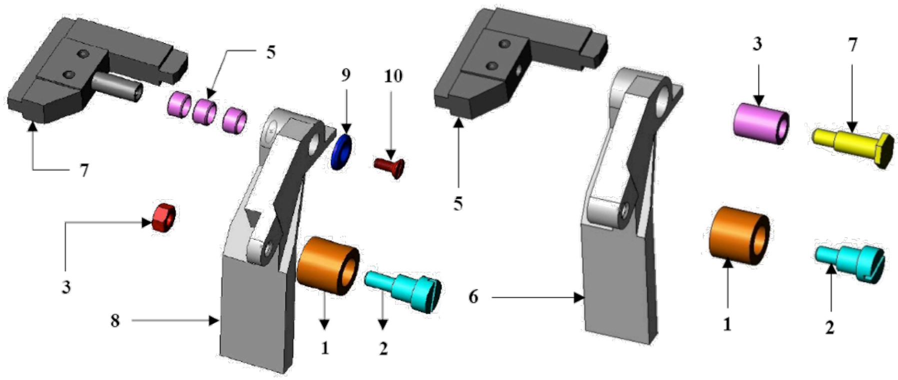
2	Bolt	1	10	1,50	38	6,00	7,50	0,02	0
3	Bushing	1	00	1,13	30	2,00	3,13	0,01	1
4	Orientation	1	-	-	98	9,00	9,00	0,03	-
5	Main Support	1	10	1,50	31	5,00	6,50	0,02	1
6	Package Expeller	1	10	1,50	16	8,00	9,50	0,03	1
7	Threated Pin	1	10	1,50	38	6,00	7,50	0,02	0
TOTAL							50,13	0,15	4

DFA Index = 4 x 3 / 50,13 = **% 23,9**

Comparison



	Part Number	Total Time (s)	DFA Index	Assembly Cost (YTL)	Material & Manufacturing Cost (YTL)	Total Weight (kg)
Current Design	10	93,09	%12,9	0,28	259,70	0,65
New Design	6	50,13	%23,9	0,15	250,30	0,69