ME 1110 – Engineering Practice 1

Engineering Drawing and Design - Lecture 11

Engineering Design Process – Part 1
Problem Definition

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www.staff.city.ac.uk/~ra600/intro.htm

Objectives for today

- What is Engineering Design Process
- Learn first 5 phases in the Process
- Coursework DE1

Products

Classical definition:

» Products are artifacts (i.e. artificial objects) made by industry in order to fulfill society needs.

Conventional industrial economy is currently shifting to a service economy. In that light, the notion, role and appearance of products are all drastically changing with current economical changes.

Progressive definition:

» Products are flexible systems (packages) of artifacts and/or services aimed to fulfill society needs in sustainable ways.

Products are important not for themselves - but for the advantages they provide.
As products and services are merging into systems, the connection between artifact and process becomes dominant.

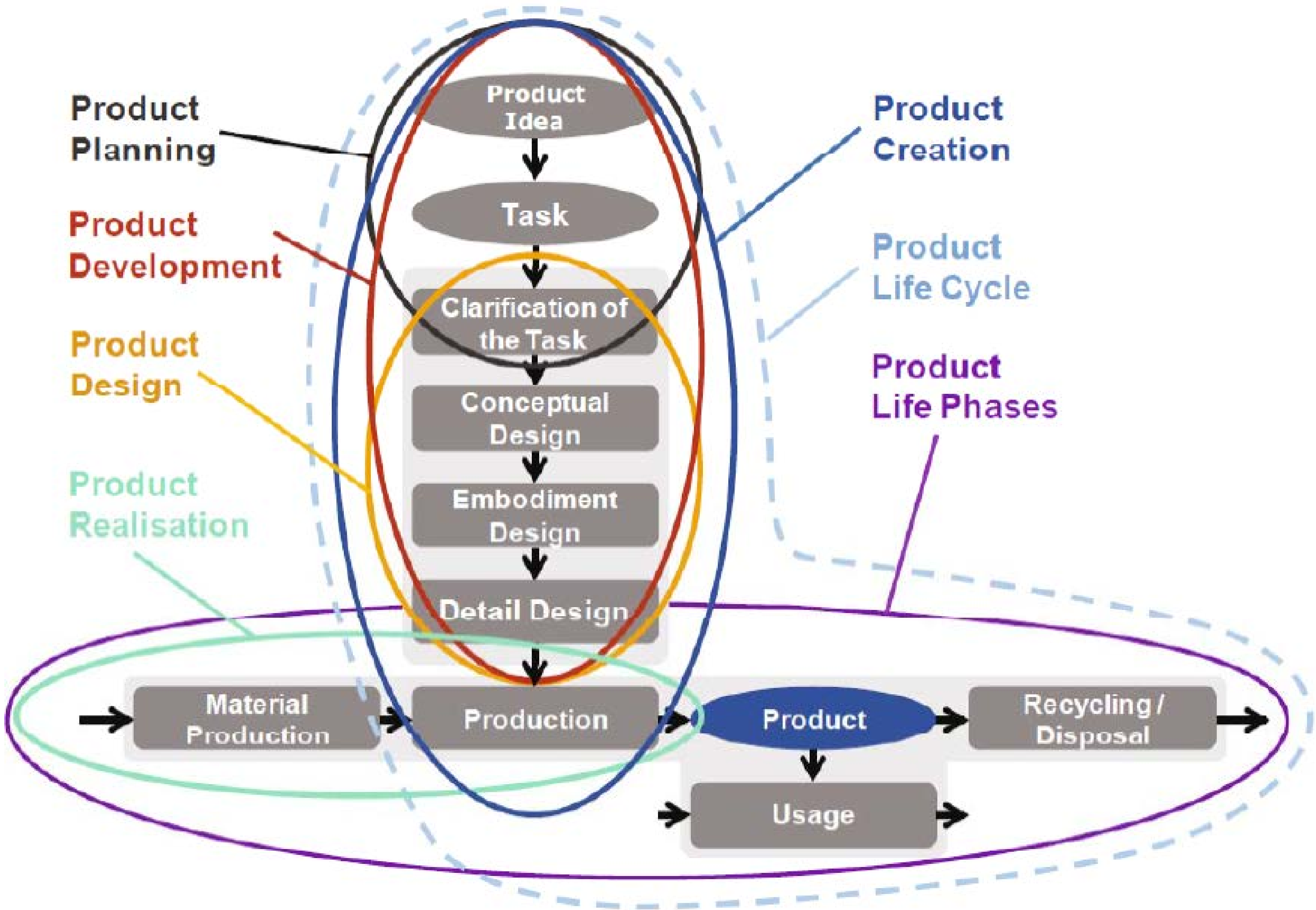
Design web

Engineers - Designers

- Engineers:
  - » Provide ways to meet needs and wants of society
  - » Invent or design new products and processes
  - » Improve existing products and processes
  - » Work in teams throughout the design process

- Bottom line:
  - » ENGINEERS ARE DESIGNERS

Position of Design in Product Lifecycle



DESIGN in Engineering?

Design is:

- » Systematic **Process** by which solution to the needs of humankind are obtained and communicated
- » Essence of **Engineering**
- » Structured problem solving activity

Engineering Design Process is:

- » Multidisciplinary task which contains:
  - – Technological factors
  - – Social factors
- » Team iterative work

Engineering & Mechanical Design

Engineering design process

is an iterative decision making activity, to produce plans by which resources are converted, preferably optimally with due consideration for environment into systems and devices (products) to meet human needs.

(Woodson.T.T)

Mechanical design process

is the use of scientific principles and technical information along with innovations, ingenuity or imagination in the definition of a machine, mechanical device or system (product) to perform pre specified functions with maximum economy and efficiency.

(Engineering Design Council, UK)

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DS_PLM_cartoon.exe

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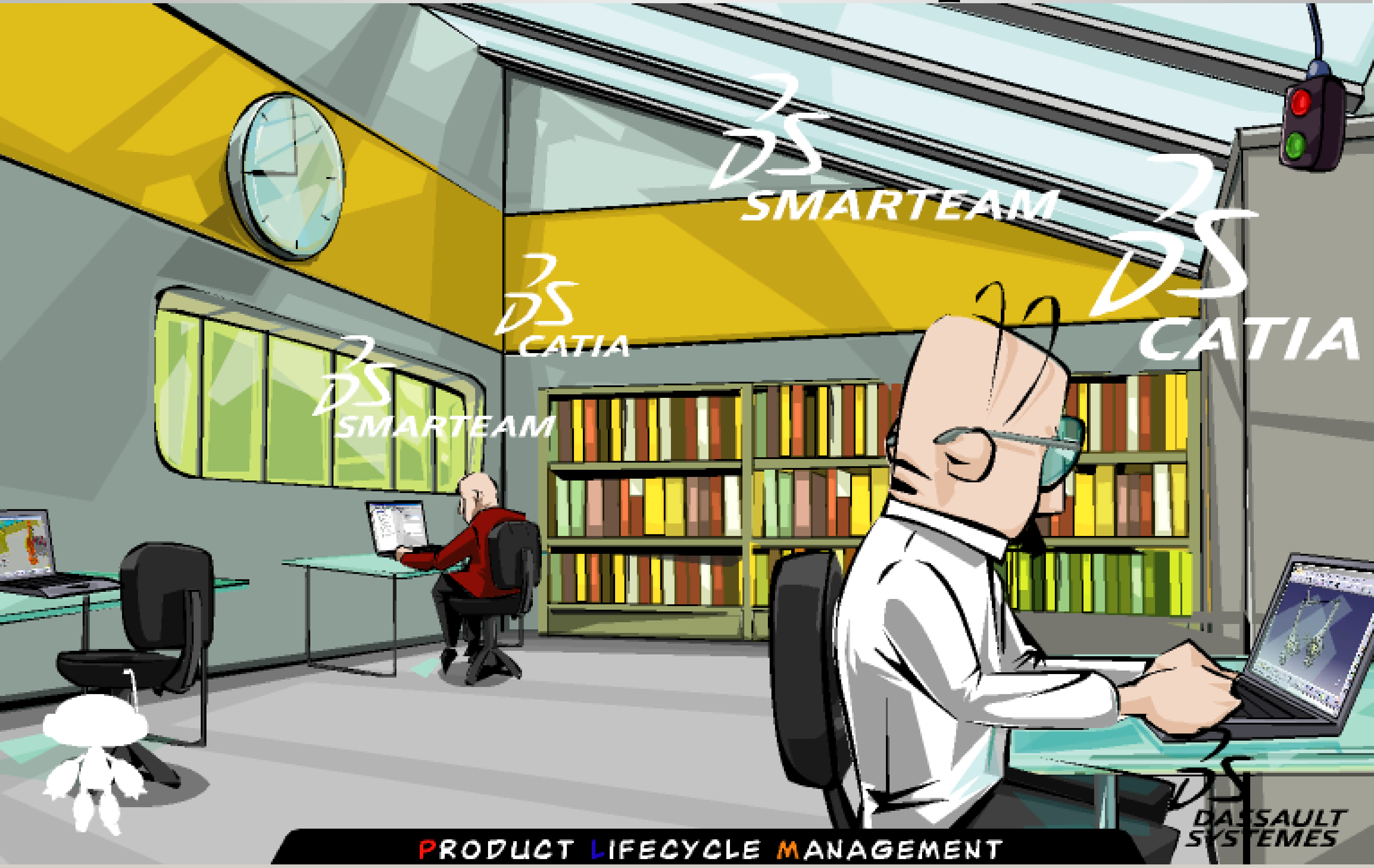
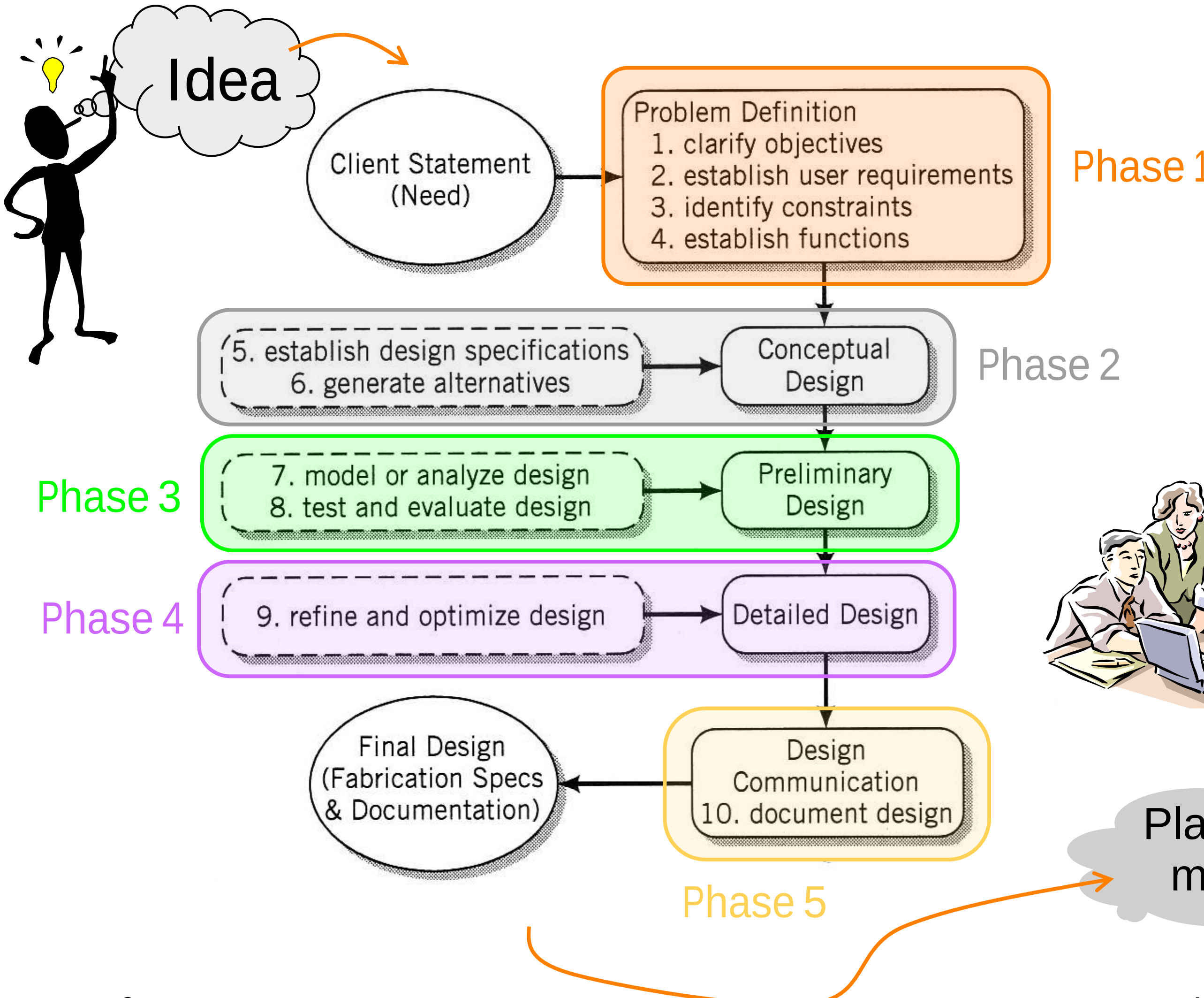
Cartoon example



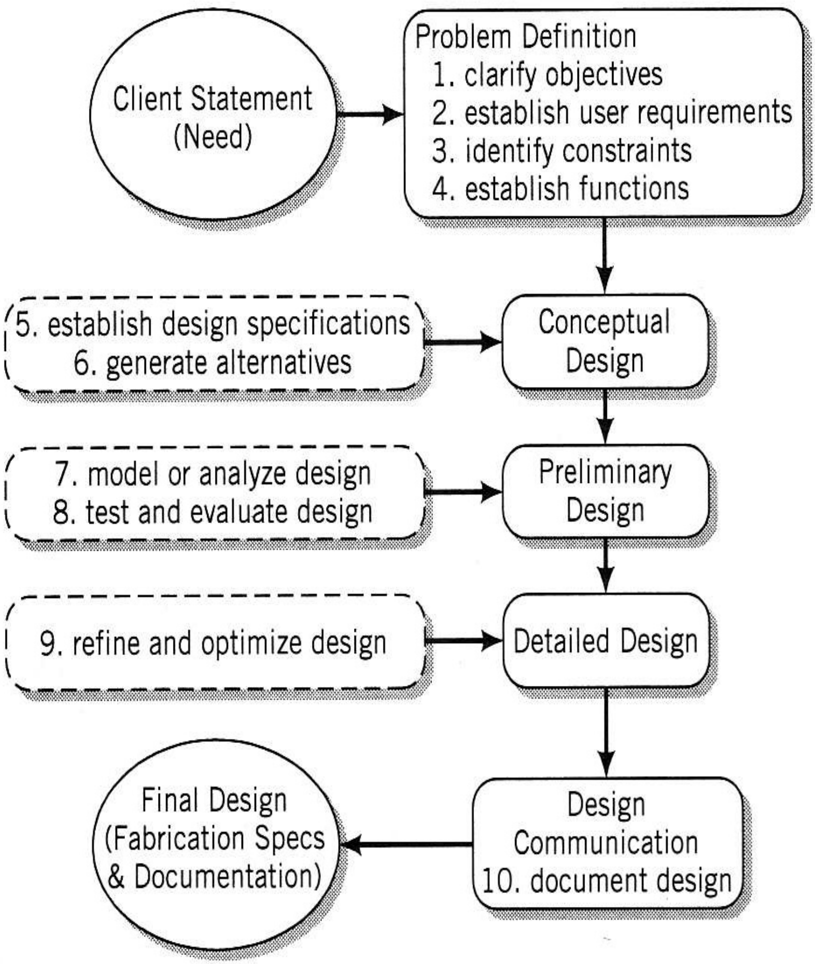
Engineering Design Process

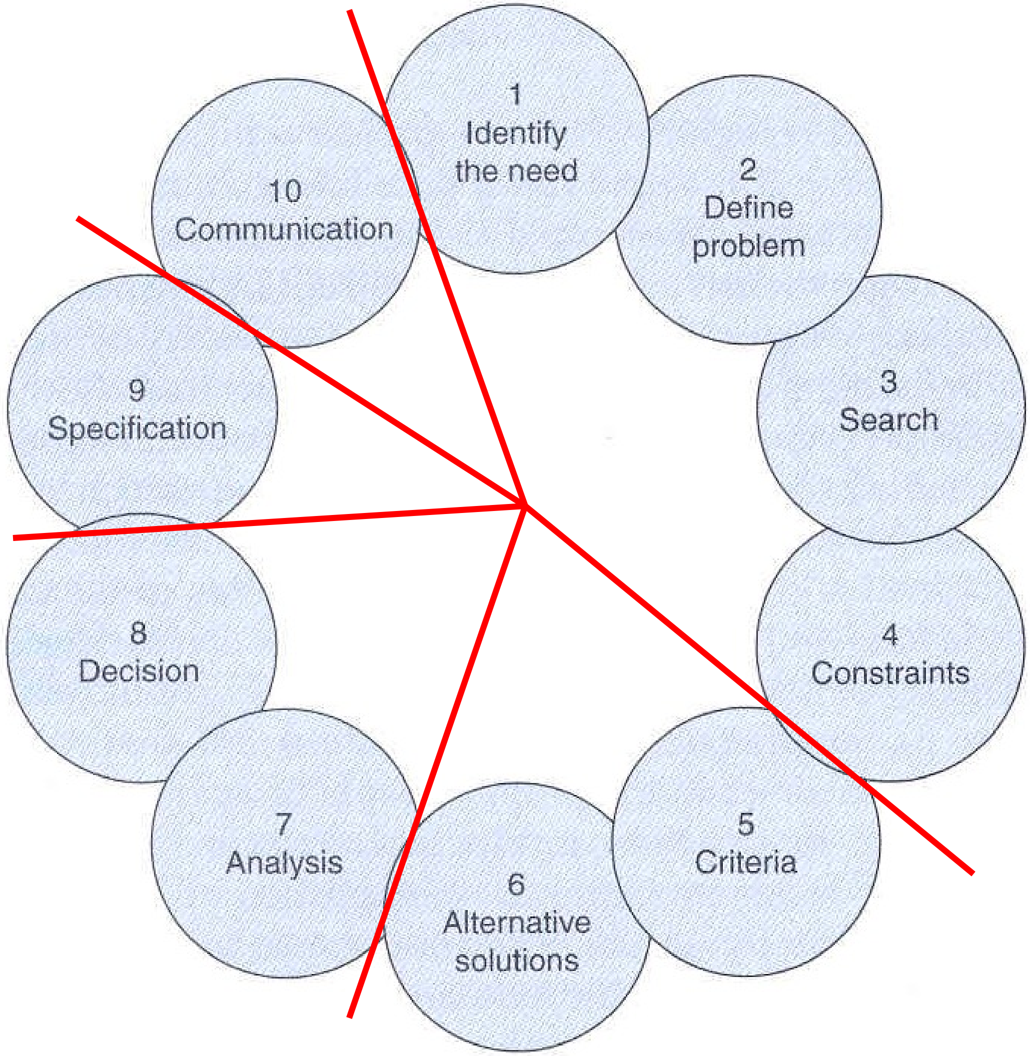


- **Design**: Structured problem solving group activity
- **Process:** Phenomenon of making changes to achieve a required result
- **Design Process:** Cyclic continuous activity of a team

Plans for product manufacturing

Engineering Design Process





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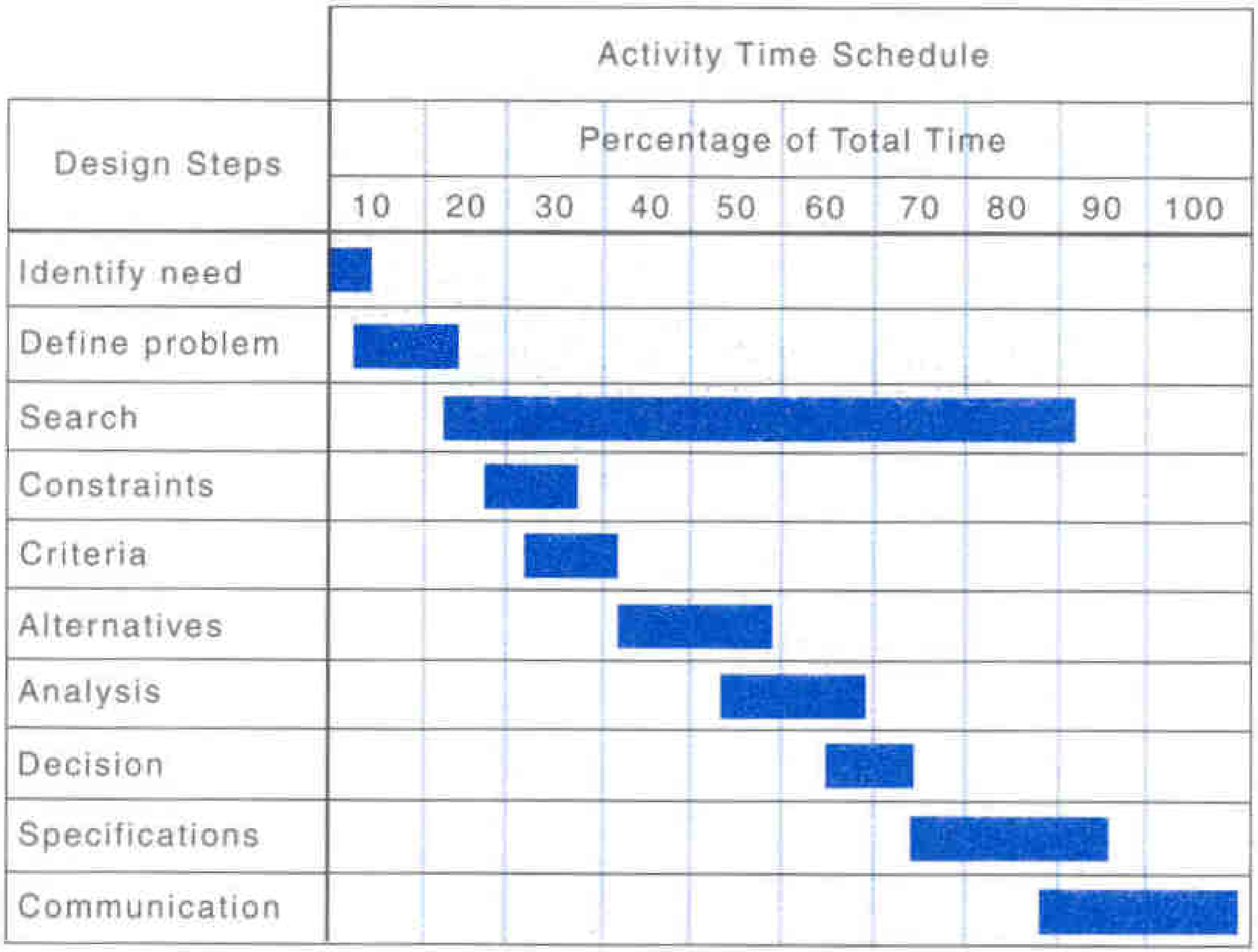
Design Process Timing



- All projects have time constraints
- An adequate planning leads to a satisfactory project finish

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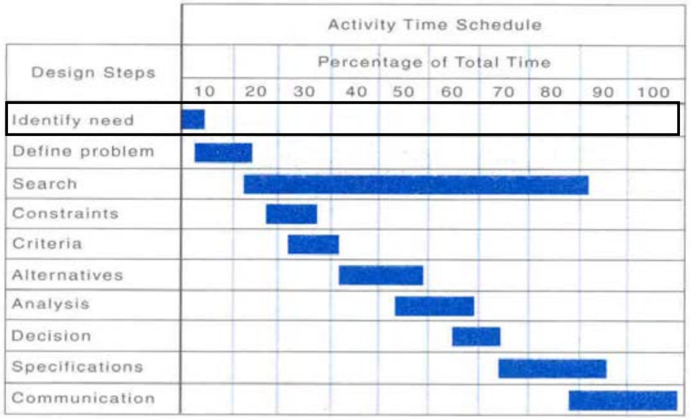
1. Identification of a Need

- **<u>Why is it important to develop/design/re-design product</u>**
- Need for constructive reaction has to be recognised before the design process starts.
- The need is relative thing. For someone a lack or shortage of something may be a necessity; for others a luxury.
- Need is often recognised by someone who is not an engineer.
- The consumers are ultimately the judges for the existence of a need.
- Engineers conduct studies only when a need is identified.



1. Identification of a Need - Example

- Dormitories – designed to accommodate 2 students and are equipped with: 2 desks, 2 closets, 2 beds, two shelving units, and one dresses.
  - » Area of a room is very limited but the rooms are reasonably high.
  - » A standardised design for all university rooms would be preferable.
  - » University needs to provide increased number of accommodations at reasonable price

2. Problem Definition - Objectives

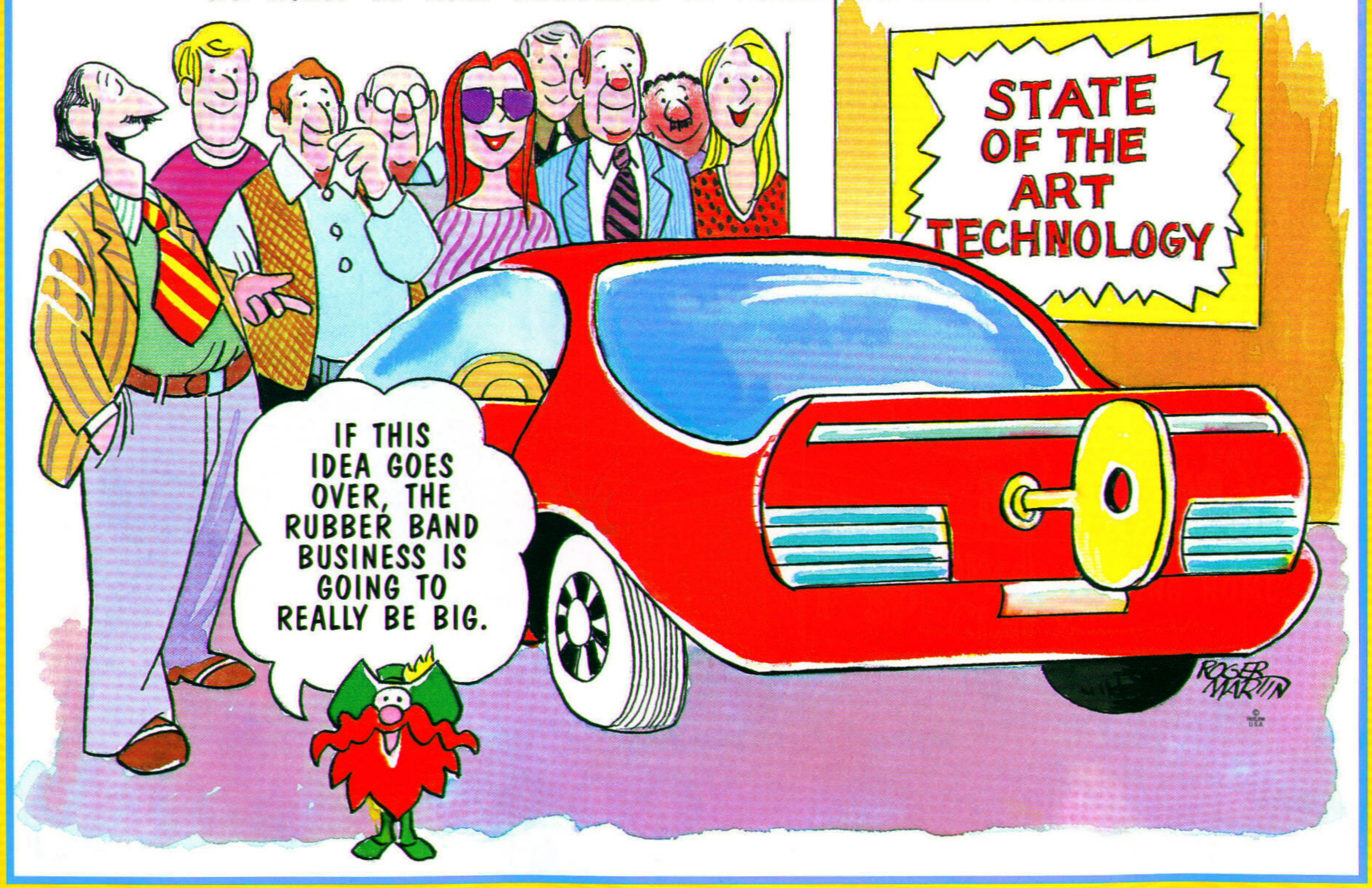
- **What are objectives (problems) to be solved in the process?**
  - » **List all objectives** or problems that exist and need to be addressed…
  - » **Do not propose solution! Instead identify objectives**.
    Often, there is temptation to construct a **quick mental picture of a solution** which will satisfy the need. Such approach limits creativity and possibilities for innovation.
  - » **Problems which may** arise: stability, **efficiency** of assembly, efficiency of use of space, university and other **regulations**.
  - » Think about qualities that product needs to have :
    - At first broadly
    - And later to define problem in detail
  - » Broad definition - possible solutions:
    - Buy a prefabricated loft system
    - Sketch a solution, obtain approval, purchase parts & assemble
    - Rent two rooms and cut a connecting door
    - Buy an existing loft system from a graduate student
    - Apply the engineering design process to find optimal system for the specified criteria

2. Problem Definition – cont.

- Symptom versus Case
  - » Story about cough, tickle, virus and aspirin:
    Treating a symptom – not attempting to solve the cause!
  - » Story about a rainfall and control the water
    To drain it quickly or to accumulate it and to drain it slowly later!?
- Solving the Wrong Problem
  - » Story about use of seat belts in USA in 1970s.
    - Increased fatalities – solution seat belt
    - driver and passengers were not willing to use it
    - Interlock system required the belts to be used before the engine starts.
    - Driver and passengers did everything to avoid the use!
  - » Or the story about students attitude in this class!?

MURPHY'S LAW

BE WARY OF NEW CONCEPTS IN POLLUTION-FREE VEHICLES.



2. Problem Definition - Example

- Answers to questions WHY? WHAT? and HOW?
- Concise and precise problem definition:
- Use a *state A* → *state B* designation
  Undesirable situation → Desirable situation
- By this means we can be sure to be solving the correct problem:

Crowded living conditions → Uncrowded living conditions

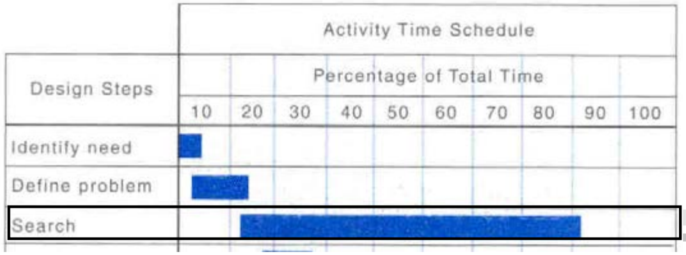
- Very broad definition which allows even buying a house, etc

Existing dorm furnishing → Existing furn. with lofted bed

- The bed loft would be designed. If other furnishing is not standard in size, then complete dormitory may be redesigned

Existing dorm beds → Lofted beds .

- This problem definition restricts the solution to lofted beds.
  It permits a wide range of possibilities – different component arrangements
  Good engineering team now needs to be sure that the problem which will be attempted is going to reflect the customer's need.



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3. Search

- **Collect required information for your project**
  - » All project contain elements of research.
  - » That is not always pleasant but has to be done for efficient design process.
- **Types of information – what is known, what is not!?**
  - » What has been written?
  - » Is something already on the market that may solve the problem?
  - » What is wrong and what is right with the way it is being done?
  - » Who manufactures the existing “solution”?
  - » How much does it cost?
  - » Will people pay for the better solution if it costs more?
  - » How much will they pay (how bad is the problem)?
- **Source of Information:**
  - » ‘Explosion’ of information in the last couple of decades – often more information than one may need.

3. Search - Continuing

- **Sources of information:**
  - » Existing solutions
    - – Reverse engineering as the possibility to understand the existing solution
  - » Internet – probably the mayor activity to get the first idea
  - » University library
  - » Government documents
  - » Professional organizations – IMechE
  - » Trade journals
  - » Vendor catalogues
  - » Individuals whom you believe are experts in the field
- **Recording of findings**
  - » Bibliography – it always has a certain form
  - » Record each reference on a card or in a computer database

Design web

3. Search - Example

Search focused on four areas:

» University restrictions and specifications

Personal interview with residence hall officers and/or others

- To meet UK, London and City University safety codes
- To be assembled with simple tools
- To have as many standard parts as possible
- Does not need a guard rail or ladder
- Does not need to be suitable for disabled people
- Preferred material wood

» Existing solutions

www.durabull.com; www.ecoloft.com; www.loftbeds.com

– **Types, availability, manufacturers, cost**

» Student preference

– Survey - students who live in halls of residence and/or used lofted beds

» Construction materials

– Used in existing solutions, strength, manufacturing process, ease of assembly, cost of the material

3. Search: Example continued

Dormitory Loft Survey

1. Do you prefer a loft system to the existing dorm room furnishings? Yes 86% No 14%

2. Would you prefer to have a loft already installed in your room? Yes 18% No 82%

3. Give reasons for your answer to question 2. —Want to customize room (no) —Don't want to be forced to use a particular loft design (no)—I don't have time to design and install a loft (yes)—

4. What would you be willing to pay for a loft system?

70%	< $100
15%	$100 − $250
10%	$250 − $500
5%	>$500

5. Rate on a scale of 1 to 10, with 10 the most important, each of the following characteristics of a loft system:

8	Durability
7	Accessibility
6	Stability
9	Cost
4	Appearance
10	Ease of assembly
8	Safety
5	Maintenance

A summary of results of the student survey on dormitory lofts. Documentation of research findings is essential if the findings are to be useful later.

4. Constraints

- **Define limitations (constraints) for the product**
- *Defining constraints will:*
  - » These will reduce number of solutions
  - » Each constraint applied the solution possibilities reduced
- *Physical and practical limitations/constraints:*

  Physical – boundary conditions
  - – Boiling and evaporating temperature
  - – Electrical voltage and frequency …

  Practical – set by the customer (market) or others
  - – Cost, competition in the market place, availability of suppliers …

4. Constraints - Example

The results of the search revealed several things that limit or eliminate solutions.

Following constraints were introduced:

- » Cost must not exceed £150
- » Loft system must meet safety and fire code regulations
- » Loft system must accommodate 78x36” mattress
- » Loft system must be freestanding and cannot affect the existing structure of the room

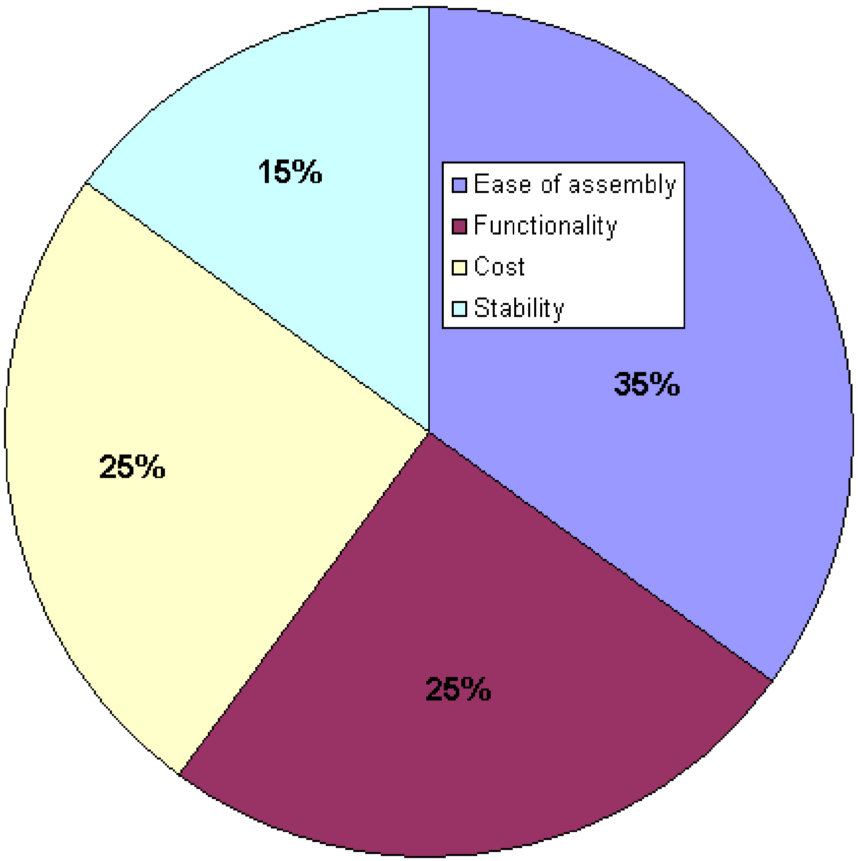
5. Criteria

- Criteria are **desirable characteristics of the solution** which are established from experience, research, market studies and customer preference
- Judgement about solution mostly on a qualitative basis
- Preferred is a mathematical definition of criteria – selection and weighting
- Ask yourself a question:

"what characteristics are most desirable and which are not applicable?"

- **The most common criteria are**:
  1. **Cost**
  2. **Reliability**
  3. **Weight**
  4. **Ease of operation and maintenance**
  5. **Appearance**
  6. **Compatibility**
  7. **Safety features**
  8. **Noise level**
  9. **Effectiveness**
  10. **Durability**
  11. **Feasibility**
  12. **Acceptance**
- Weighting – team members have to agree on that. The best is if all members of team propose their own weighting and then all agree on that

5. Criteria – Example



Design Exercise 1

Apply first 5 phases of the Engineering Design to the design of Concorde window

- Which of the two window panels normally carries the internal cabin pressure load?
- Which window panel acts as a heat shield?
- Identify 4 rubber seals in the design. Which seals serve to maintain cabin pressure?
- Why flat glass is used?
- Why the window is relatively small in area?
- By what means the window is prevented from misting up?
- How the window panel unit is removed from the fuselage structure for maintenance?