BE 102- Design and Engineering

Module 2

Module 2 - 15 % Marks

2 Hours Lecture

Design process- Different stages in design and their significance; Defining the design space; Analogies and thinking outside of the box"; Quality function deployment-meeting what the customer wants; Evaluation and choosing of a design.

3 Hours Lecture

Design Communication; Realization of the concept into a configuration, drawing and model. Concept of "Complex is Simple". Design for function and strength. Design detailing- Material selection, Design visualisation- Solid modelling; Detailed 2D drawings; Tolerancing; Use of standard items in design; Research needs in design; Energy needs of the design, both in its realization and application.

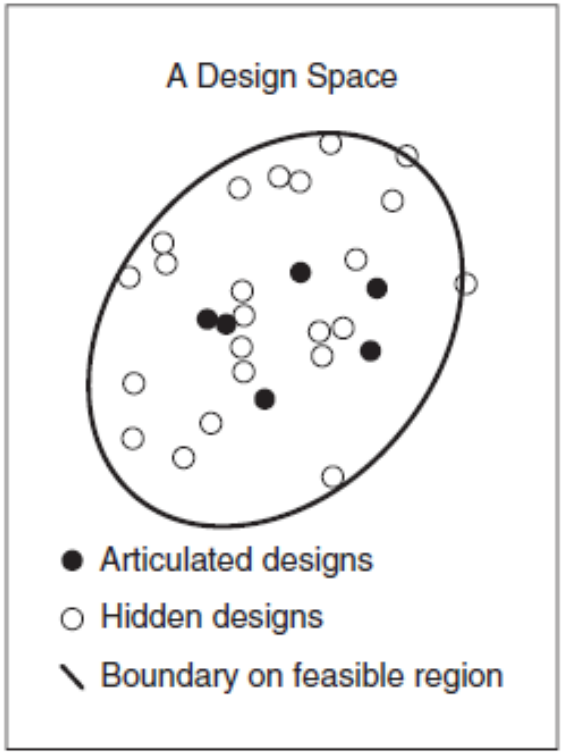
4 Hours Project

An exercise in the detailed design of two products.
(Stapler/ door/clock)

Design Space

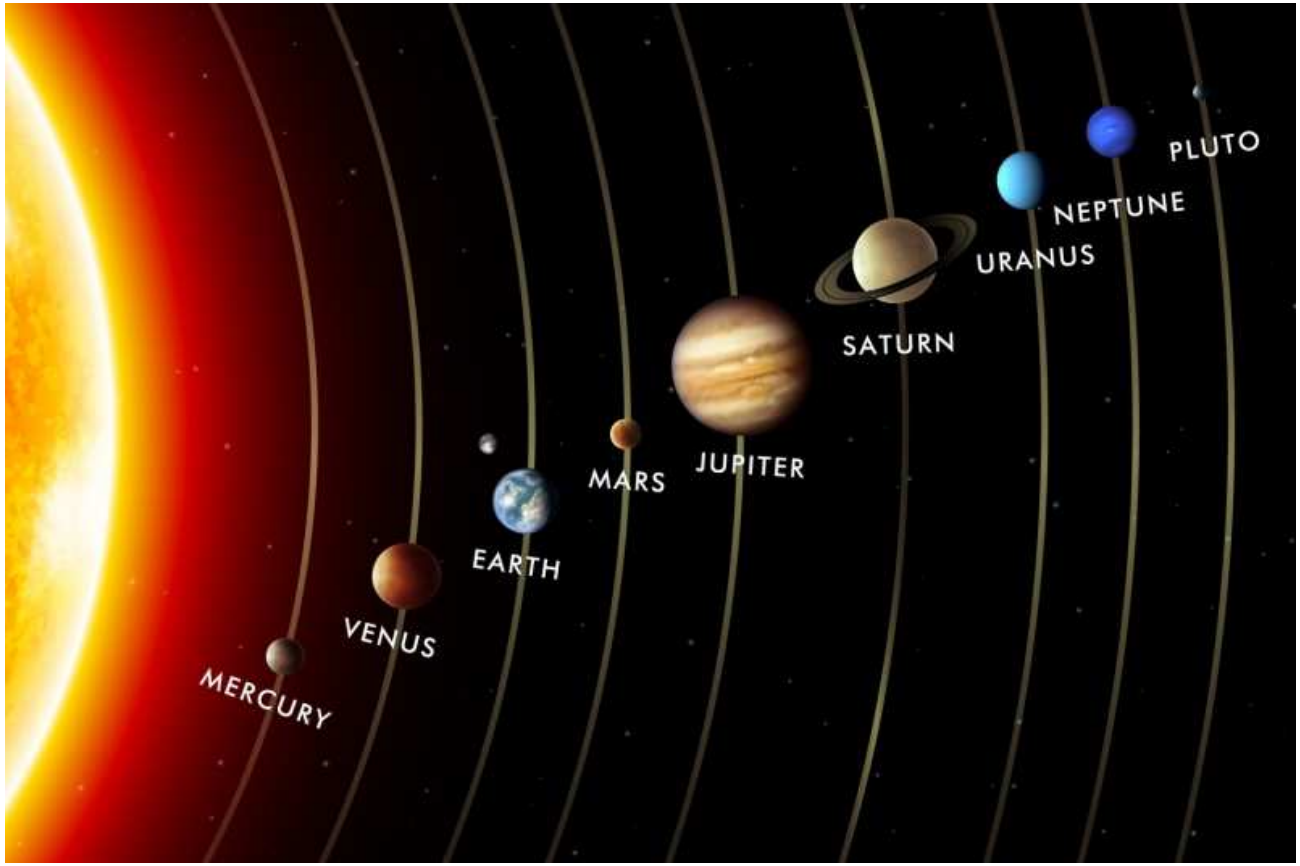
The set of all possible designs is an n-dimensional hyperspace called a design space

Where, n= The number of different engineering characteristics it takes to fully describe the design



feasible designs created in response to the articulation of a design task is pictured as a problem space or a design space that consists of states as shown in Fig.

- Each state is a different conceptual design. The space has a boundary that encloses only the feasible designs, many of which are unknown to the designer
- The space is more than three dimensions because there are so many characteristics that can categorize a design (e.g., cost, performance, weight, size, etc.)



A stationary solar system is a useful analogy for a design space

Design Space Analogy

A stationary solar system is a useful analogy for a design space.

- ✓Each planet or star in the system is different from the others.
- ✓Each known body in the space is a potential solution to the design task.
- ✓There are also a number of undiscovered planets and stars.
- ✓These represent designs that no one has articulated.
- ✓The vastness of outer space is also a good analogy for a design space.

There are many, many, many, different solutions for any design problem. The number of potential solutions can be as high as the order of n where n is equal to the number of different engineering characteristics it takes to fully describe the design.

DESIGN SPACE

- **An imaginary intellectual region of design alternatives that contains all of the potential solutions to our design problem.**

the vastness of the possibilities.

- **Larger design space means many design options.**
- **New & unfamiliar designs will have small design space.**

  Design of a house?

  Design of a car?

  Design of a pencil?

  Design of a pen?

  Design of a portable drilling machine?

- **Brainstorming, Research & Experiments, Analogies**

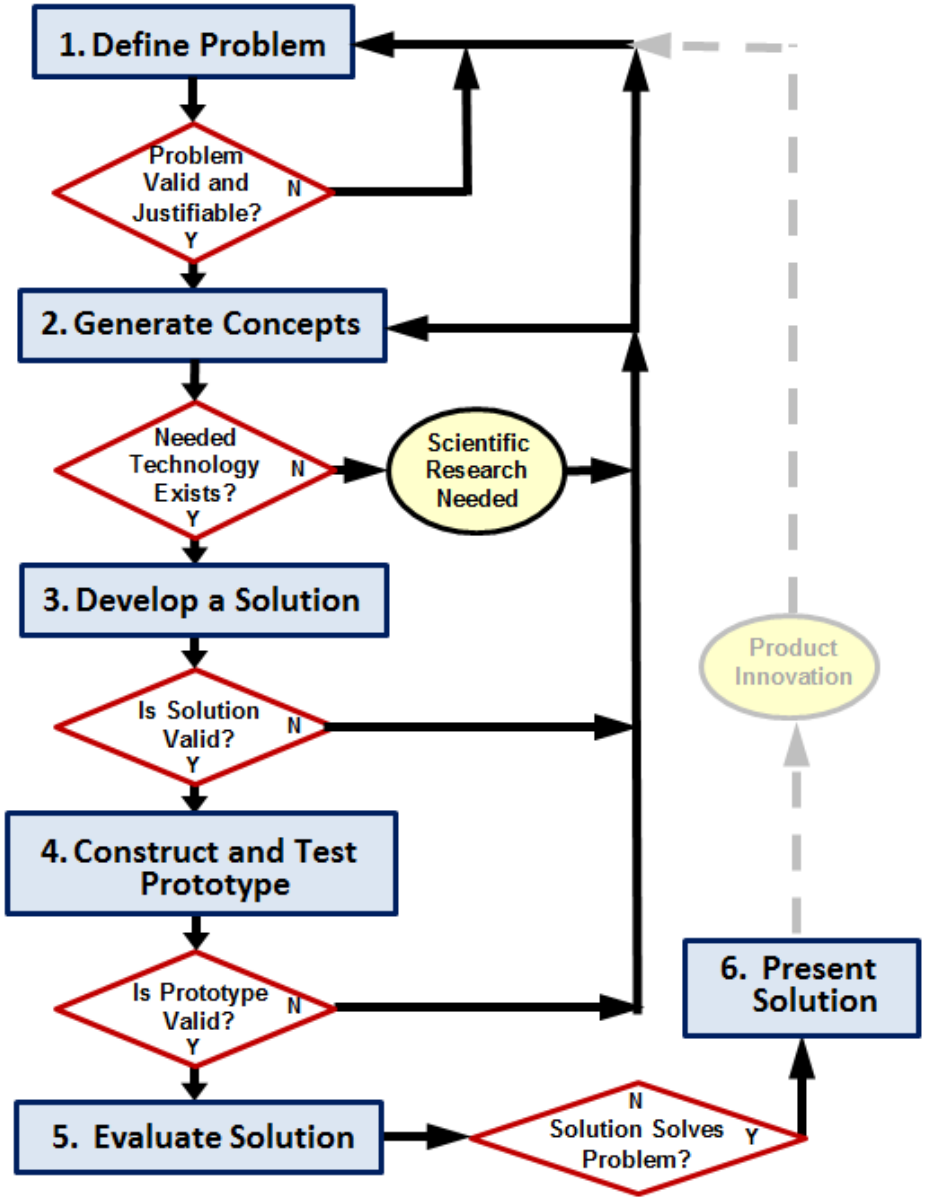
Design Process

Designs did not miraculously appear but originated in the minds of human beings and took time to develop.
Engineering is the creative process of turning abstract ideas into physical representations (products or systems).

‘There are scientific methods that everyone can adopt to develop optimised DESIGNS’

Design Process

1. Define the Problem
2. Generate Concepts
3. Develop a Solution
4. Construct and Test a Prototype
5. Evaluate the Solution
6. Present the Solution



STRUCTURED DESIGN PROCESS

Design process has following stages:

1.Product or Problem identification

2.Problem Definition

3.Design goals and functions

4.Gathering data/new knowledge (via Research)

5.Brainstorming and ideation

6.Evaluation of potential solutions

7.Conceptual design

8.Design Detailing

STRUCTURED DESIGN PROCESS

9. Standardization needs
10. Prototyping
11. Testing
12. Design Modifications
13. Freezing the design
14. Cost analysis
15. Realization/Manufacturing
16. Quality Assurance
17. Feed back analysis for design improvement.

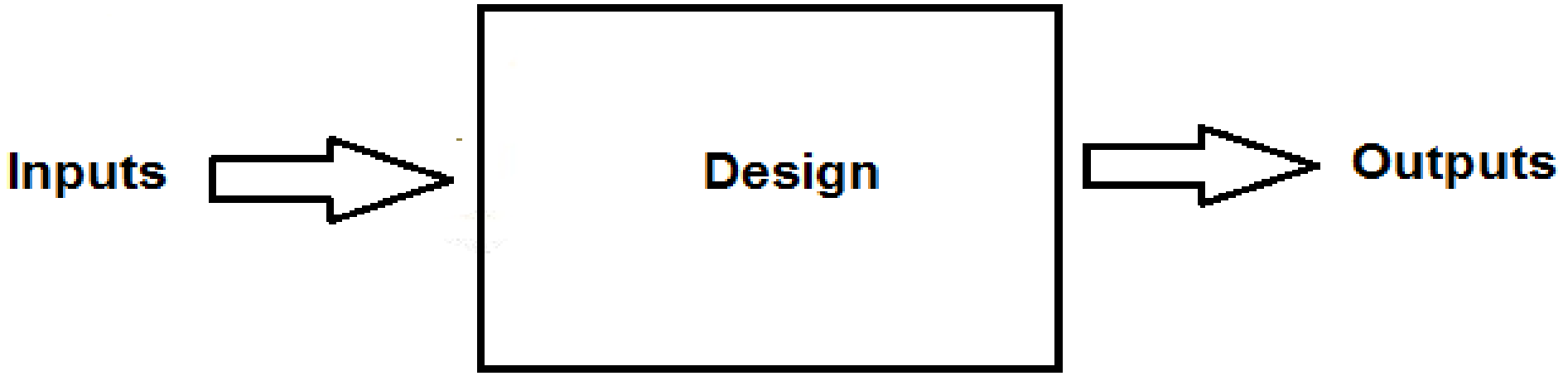
Define the Problem

- Identify a problem
- Validate the problem
  - *Who says it is a problem?*
  - *Needs and wants*
  - *Prior solutions*
- Justify the problem
  - *Is the problem worth solving?*
- Create design requirements (specifications)
  - *Criteria and constraints*
- *Design Brief*


QUALITEX

FUNCTIONAL ANALYSIS

logical approach for describing the transformation between the initial and final states of a system or device.



- **To focus on the design one has to understand the functions based on the input to achieve the output.**

Define the Problem

- Design Brief
  - A written plan that identifies a problem to be solved, its criteria, and its constraints.
  - Used to encourage thinking of all aspects of a problem before attempting a solution.

Define the Problem

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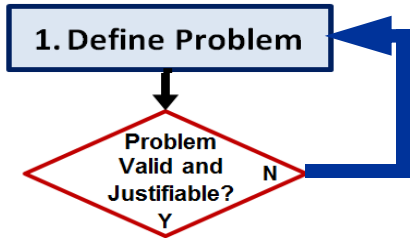
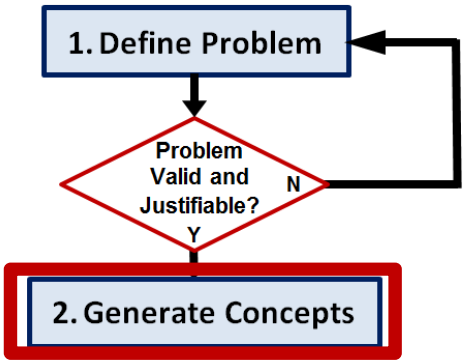


In some cases, if the problem is not valid or justifiable, the designer must define a new problem.

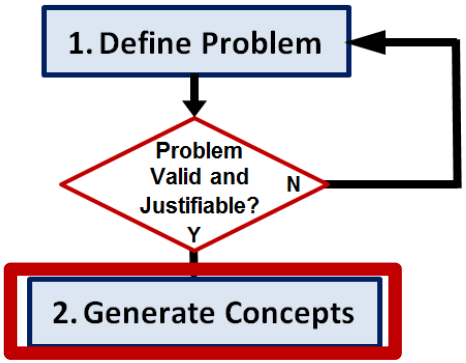
Generate Concepts

- Research
- Brainstorm possible solutions
- Consider additional design goals
- Apply STEM principles
- Select an approach
- *Decision Matrix*



Generate Concepts

- *Decision Matrix*
  - A tool used to compare design solutions against one another, using specific criteria.



	cost	complexity	Development Time	Total
Idea #1	3	2	1	6
Idea #2	1	1	2	4
Idea #3	4	2	4	10
Idea #4	2	3	4	9
Idea #5	4	1	3	8
Idea #6	3	4	4	11

4	3	2	1
Best			Worst

2	1
Yes	No

Generate Concepts

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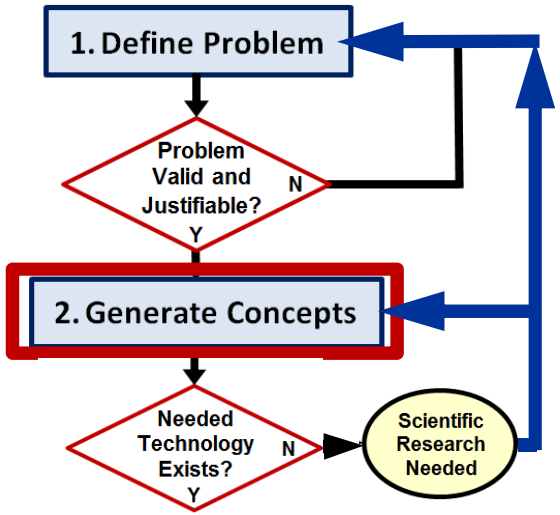
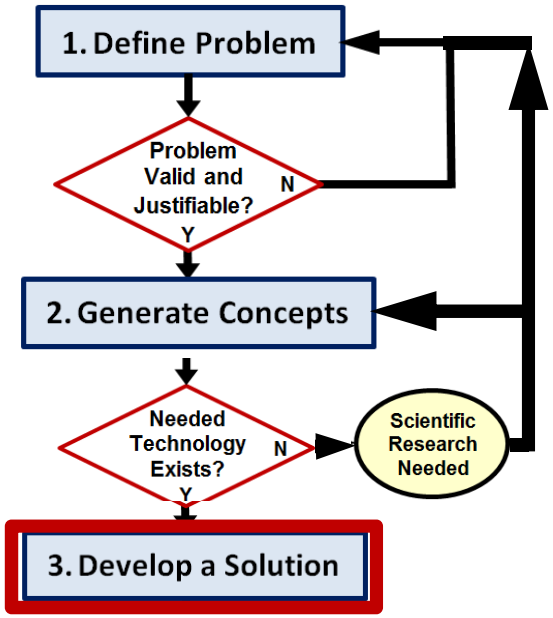
- *Decision Matrix*



If the technology necessary to develop the solution does not exist, scientific research may be necessary to pursue a solution.

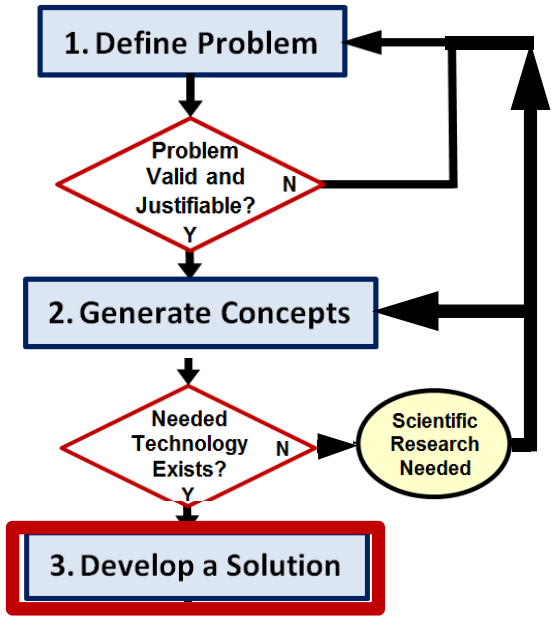
Develop a Solution

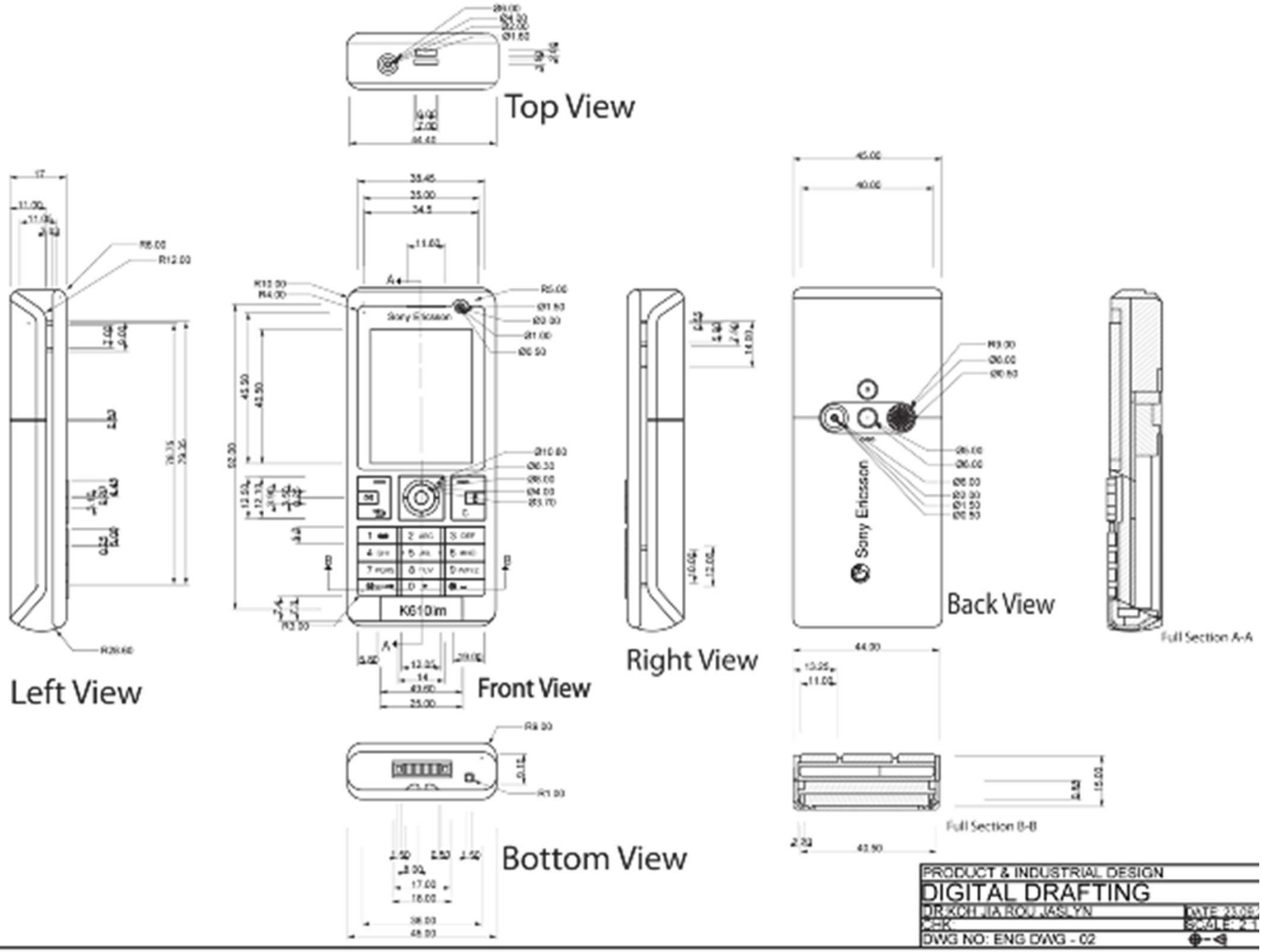
- Create detailed design solution
- Justify the solution path
- *Technical Drawings*

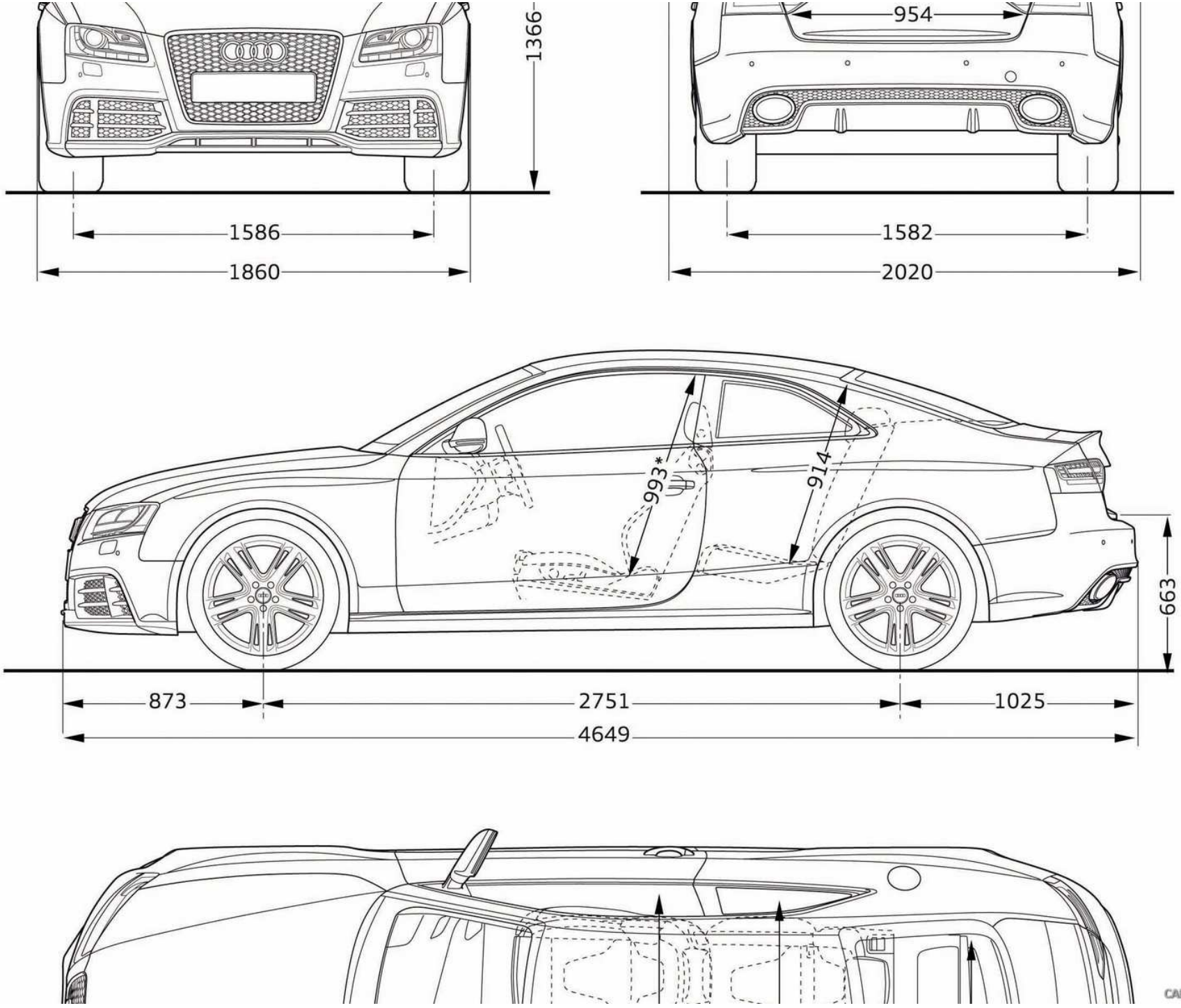


Develop a Solution

- *Technical Drawings*
  - Drawings that provide technical information necessary to produce a product.
    - material, size, shape
    - assembly, if necessary

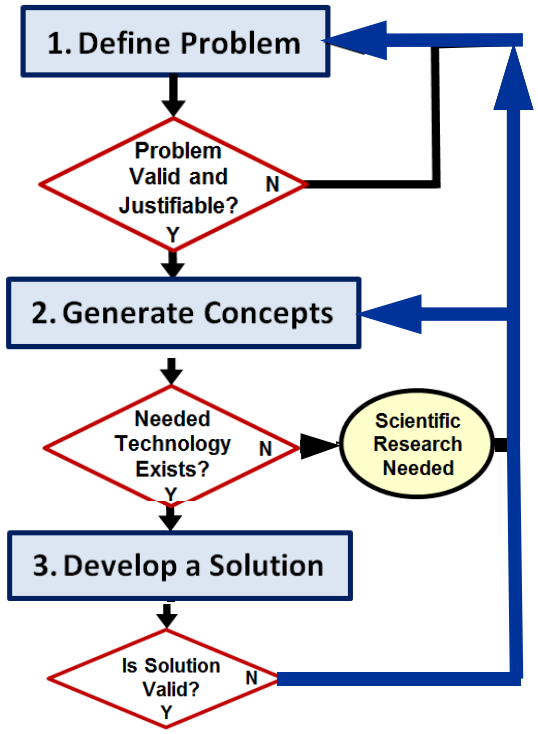



Top View
Left View
Front View
Right View
Back View
Full Section A-A
Full Section B-B
Bottom View
Sony Ericsson
K610m
PRODUCT & INDUSTRIAL DESIGN
DIGITAL DRAFTING
DR:KOH JIA ROU/ASLYN
CHK:
DWG NO: ENG DWG - 02
DATE: 23/05/
SCALE: 2:1



Develop a Solution

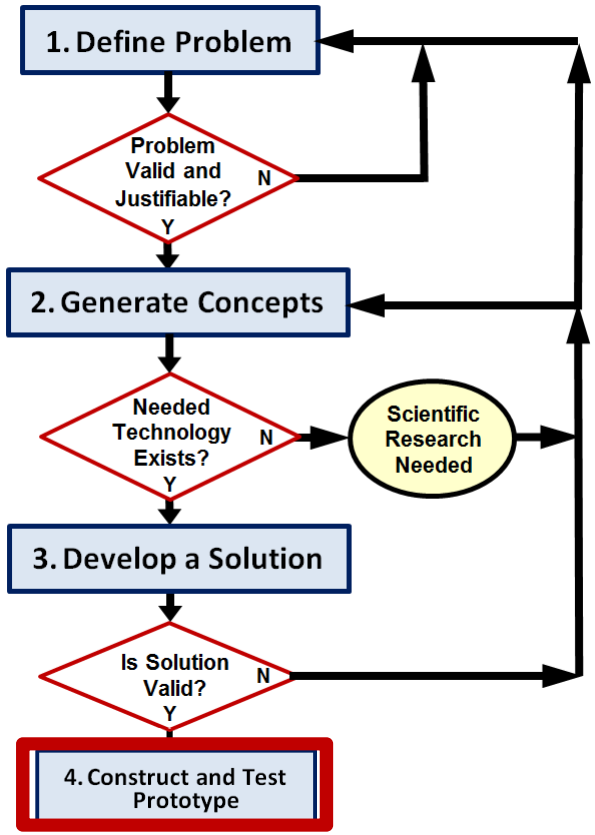
- Select an approach
  - *Decision Matrix*
- Create detailed design solution
  - *Technical Drawings*
- Justify the solution path

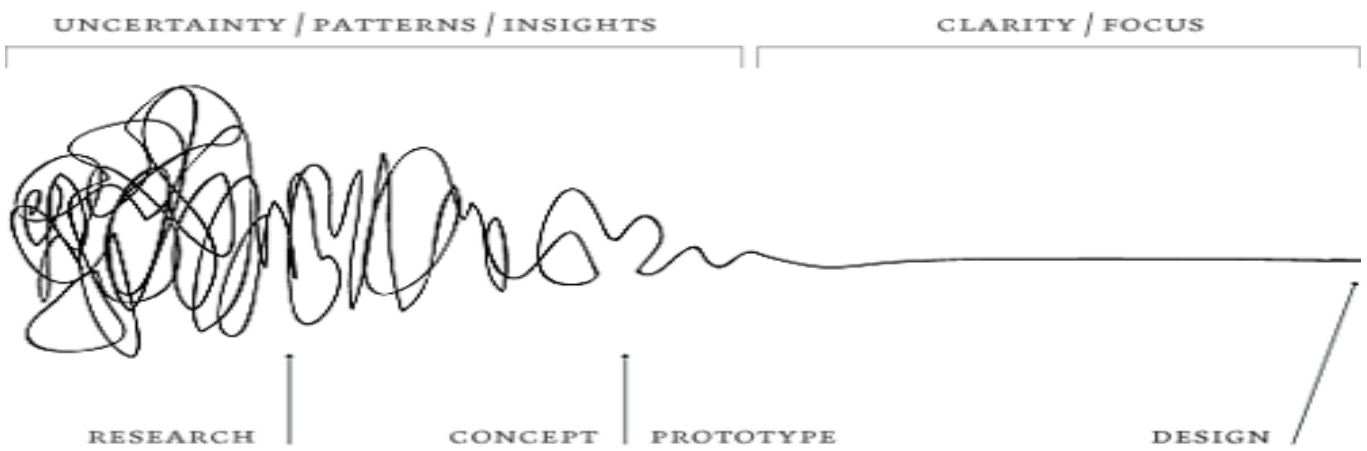


If a solution is found to be invalid or cannot be justified, the designer must return to a previous step in the design process.

Construct and Test a Prototype

- Construct a testable prototype
- Plan prototype testing
  - *Performance*
  - *Usability*
  - *Durability*
- Test prototype
  - collect test data
  - analyze test data
- *Test Report*





Prototyping: The first stage of testing and implementation of a new product, called prototyping, consists of building a prototype of the product-the first fully operational production of the complete design solution. A prototype is not fully tested and may not work or operate as intended. The purpose of the prototype is to test the design solution under real conditions.

Aircraft wind tunnel test

Construct and Test a Prototype

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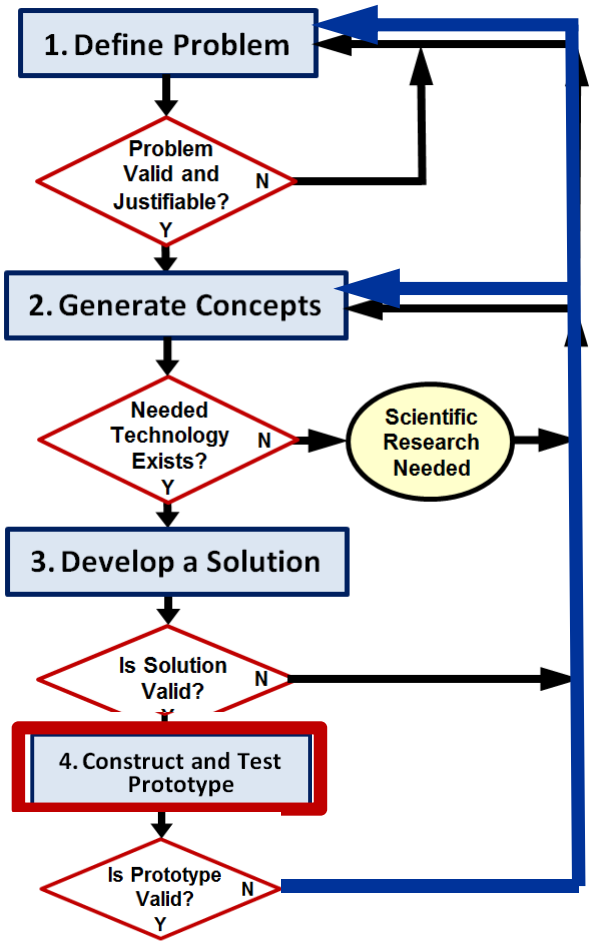
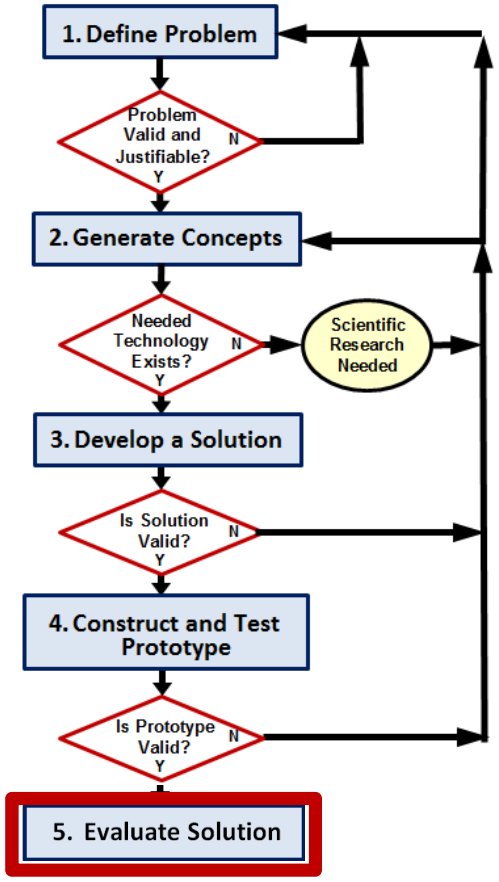


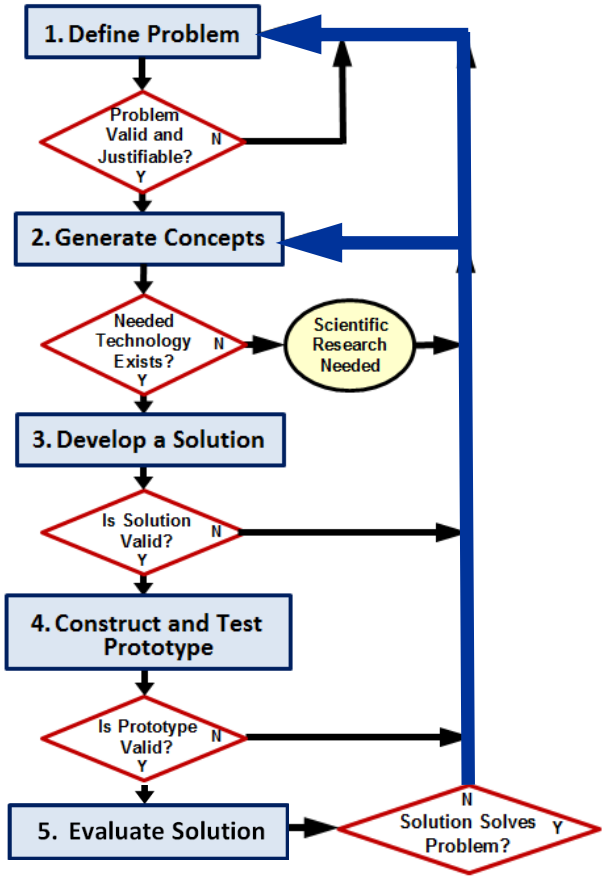
If a testable prototype cannot be built or test data analysis indicates a flawed design, the designer must return to a previous step of the design process.

Evaluate the Solution

- Evaluate solution effectiveness
- Reflect on design
  - *Recommend improvements*
- Optimize/Redesign the solution
  - *[Return to prior design process steps, if necessary]*
  - *Revise design documents*
- *Project Recommendations*



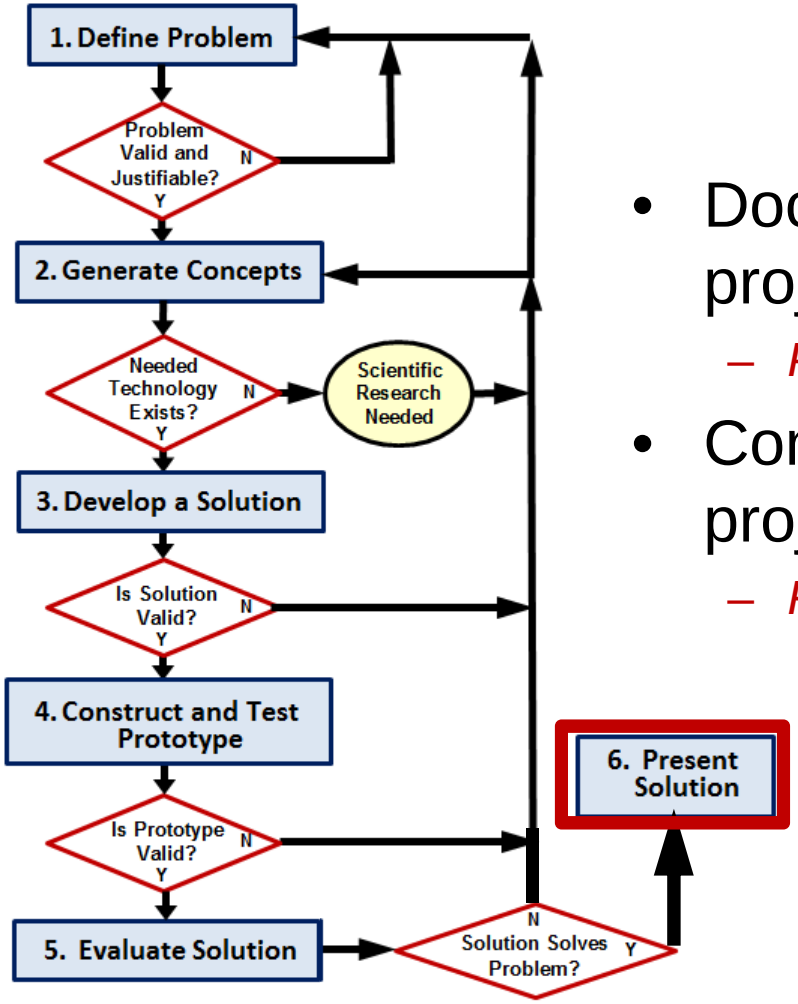
Evaluate the Solution



Does the solution solve the problem?

If not, the designer must return to a previous step of the design process.

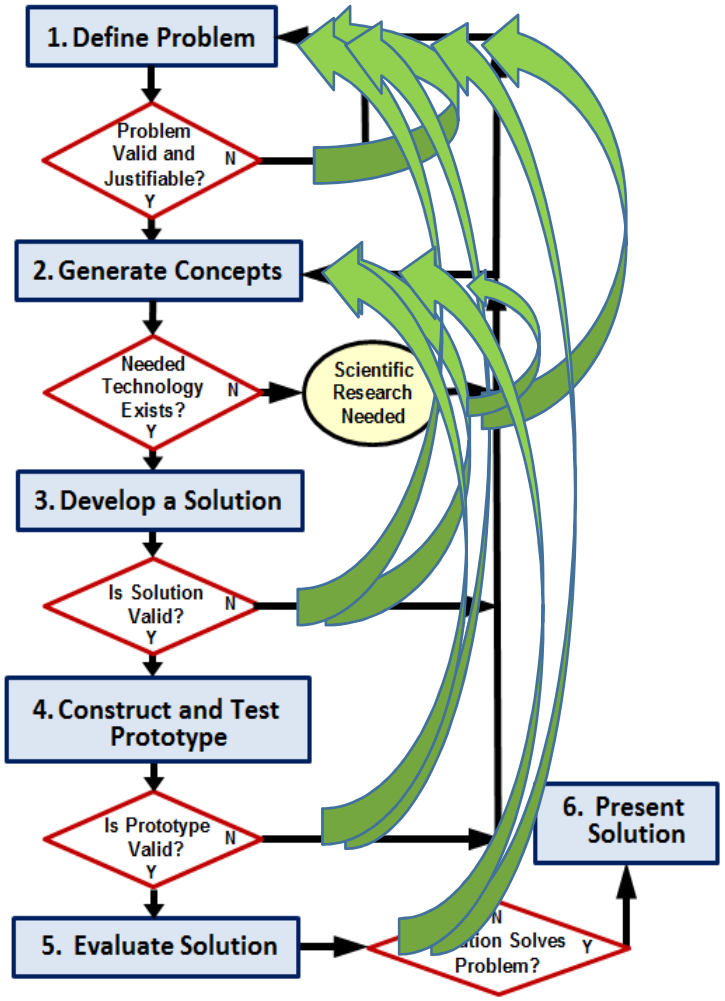
Present the Solution



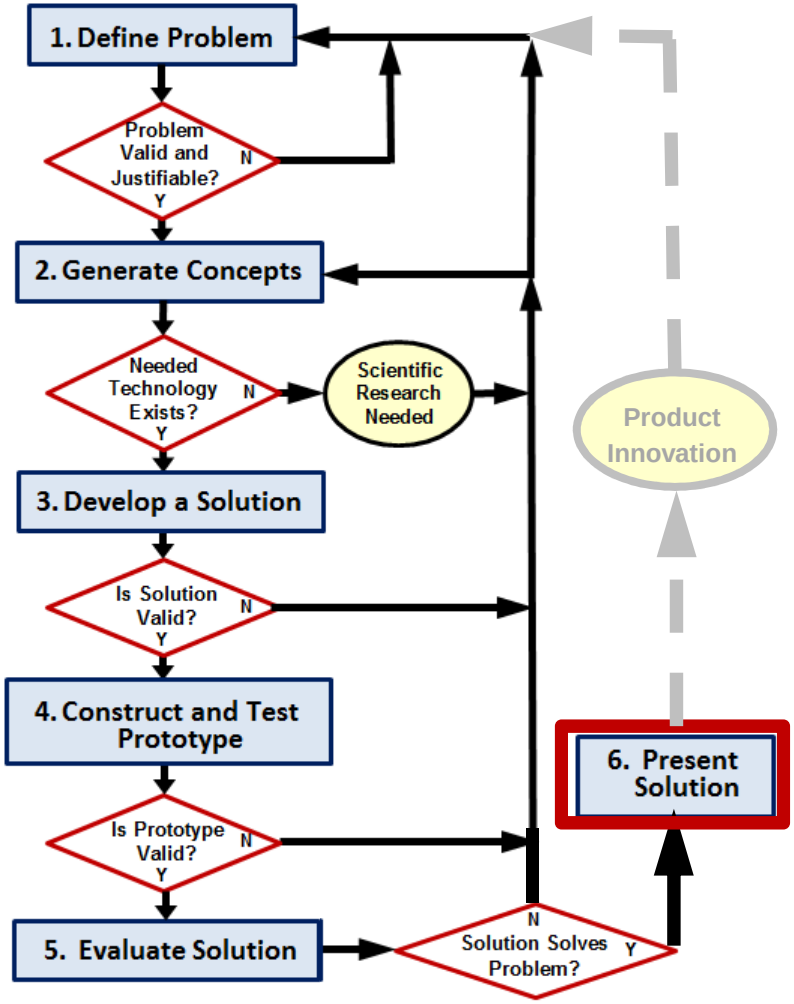
- Document the project
  - *Project Portfolio*
- Communicate the project
  - *Formal Presentation*

Design Process

- Iterative



A Design Process



Product improvement or redesign will require the designer to repeat the design process.

Detailed Design Process

12. Communicate Results

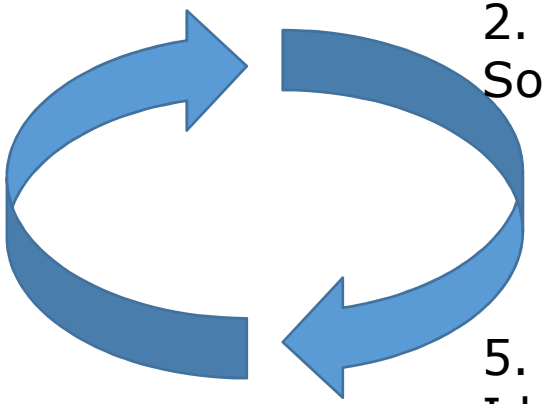
11. Refine/Create

10. Test & Evaluate

9. Prototype

8. Develop Written Design Proposal

7. Select an Approach



1. Define a Problem

2. Brainstorm Possible Solutions

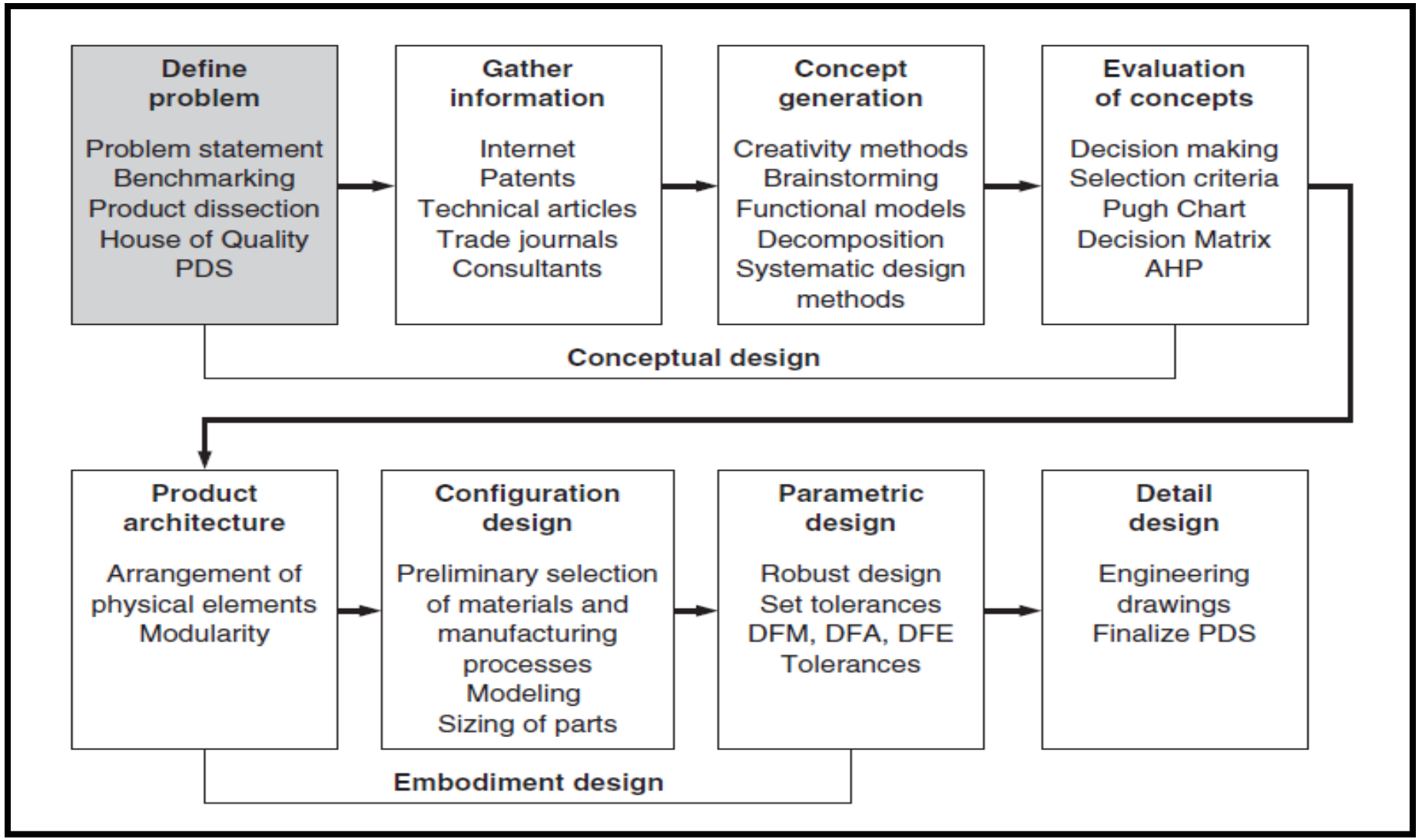
3. Generate ideas

4. Research Ideas & Explore Possibilities

5. Specify Criteria & Identify Constraints

6. Consider Alternative Solutions

Product Development Process

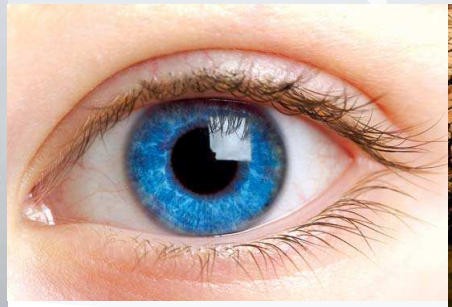


REALIZATION/MANUFACTURING

- **The product is set in for manufacturing.**
- **Bulk production of artefact is carried out.**
- **It is made ready for customers**

Analogies in Design & "Thinking Out Side the Box"

- **This involves relating the existing problem to some segments of solved problems.**
- **This gives possible solutions from existing solutions.**
- **Biomimetic : Analogies from nature.**

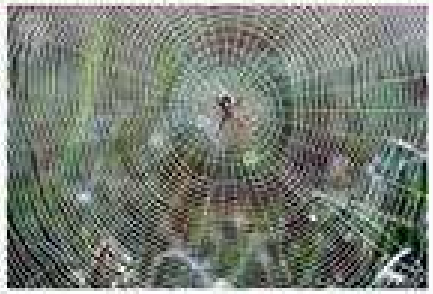





Inspiration Naturally!!!

Plant: the energy reservoir

www.gardeningoncloud9.com

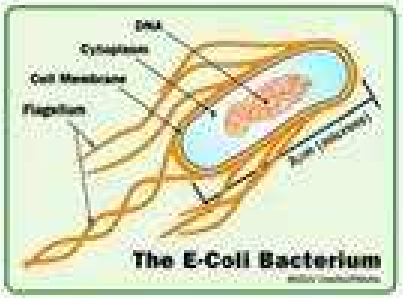


Spider silk: tough materials

www.tehrantimes.com

Bird: the natural airplane

http://www.guidetobelize.info



Flagellum: the mechanical motor

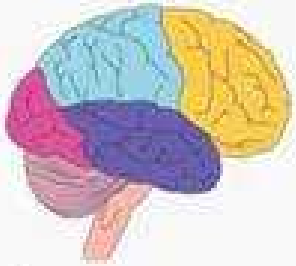
http://creationrevolution.co

Lotus leaf: hydrophobic surface

http://sustainabledesignupdate.com

Eye: nature's best camera

www.photoshopstar.com



Brain: the super computer

www.healthguide.howstuffworks.com

Termites mound the natural cooler

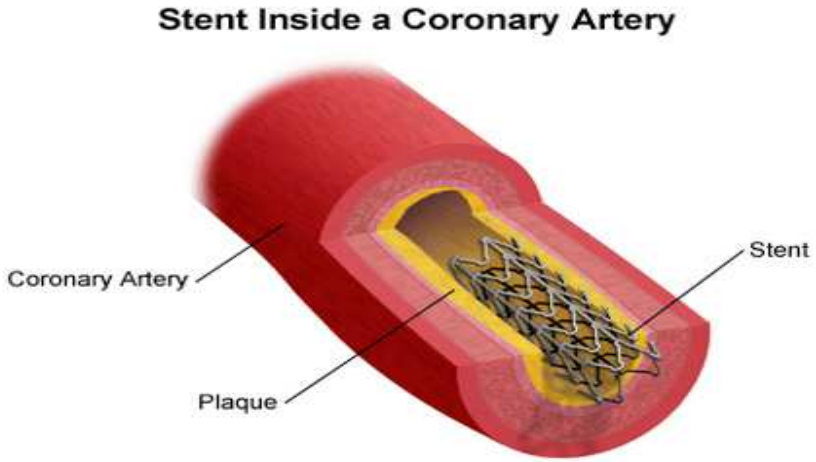
www.animals.howstuffworks.com

Dolphins the best ship

www.ashoature.org

"Think outside the box" "Stretch the envelope"

- **Idea of going into depth of ocean / flying like birds where considered impossible and preposterous!!!!!**
- **Idea of stealth aircraft developing based on bat wings.**
- **Stent for coronary angioplasty. Innovative designs\Video 8 Angioplasty Procedure**



THINKING OUTSIDE THE BOX

We are all in a box. We are surrounded by things that are well known to us. We see how people behave, how they react, what they say, what they use, how they use and so on.

Such a surrounding envelopes us.

WE ARE IN A BOX !

If you want to be different (creative) then thinking and doing differently is the only option.

So think outside the box.

THINKING OUTSIDE THE BOX

To be creative, step out of the box, change your mindsets and attitudes, leave all your experiences behind and start to look at things from different perspectives.

Think of crazy ideas that are non workable at the first thought.

Bring in negative approaches to look at the situation.

Be uninhibited and unbiased and open for suggestions.

Go against the tide- question the popular approaches.

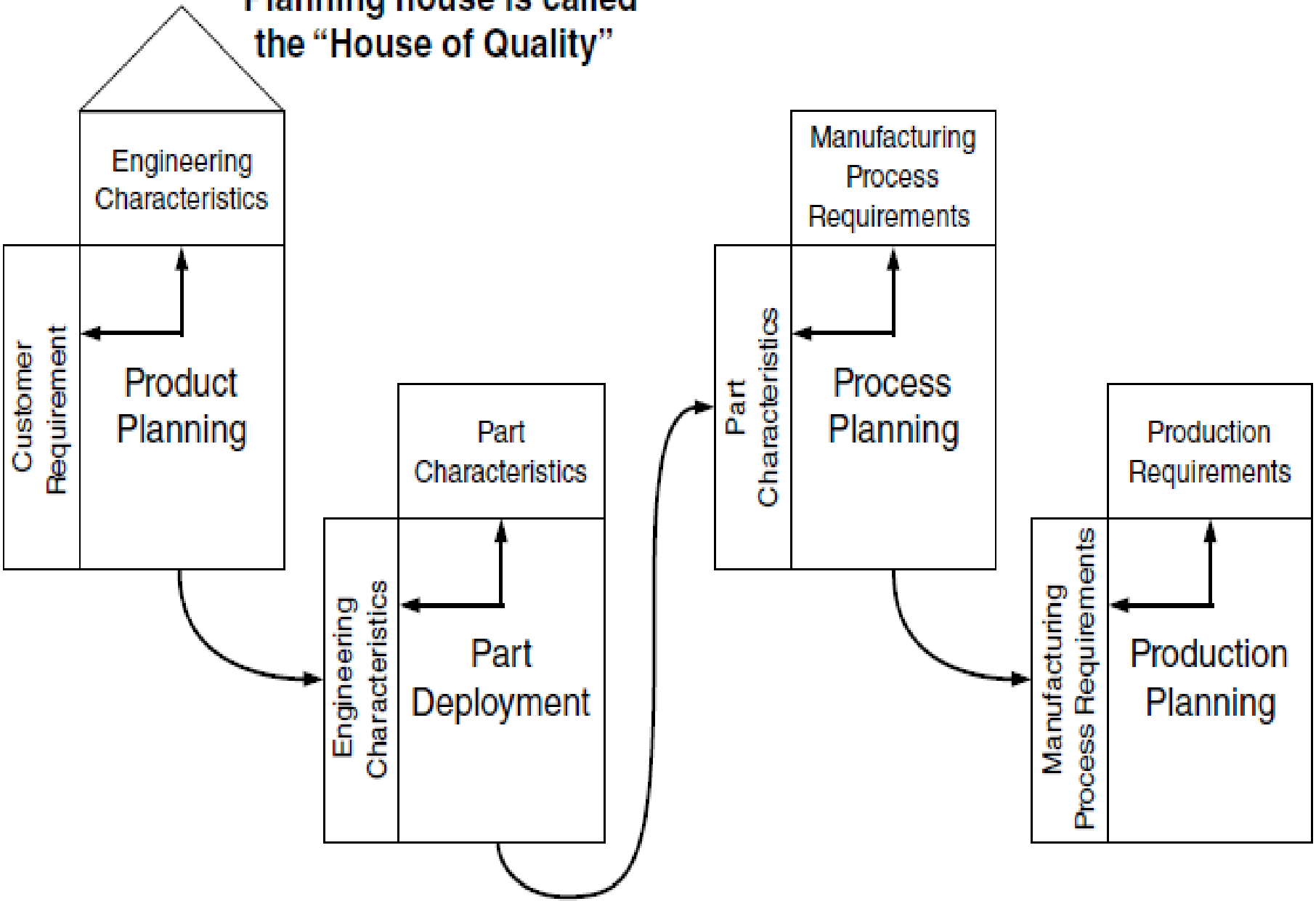
QUALITY ASSURANCE

- ***Quality assurance (QA) is a way of preventing mistakes or defects in manufactured products and avoiding problems when delivering solutions or services to customers.***
- ***focused on providing confidence that quality requirements will be fulfilled.***
- **Various bodies are present to check the quality**
  - **ISO – International organisation for standardization**
  - **CMMI- Capability Maturity Model Integration**
- **Statistical Methods are also used for Quality control**

QUALITY FUNCTION DEPLOYMENT

- **A planning and team problem-solving tool.**
- **Focusing attention of design team on satisfying customer needs throughout the product development process.**
- **A methodology for infusing *the voice of the customer* into every aspect of the design process.**
- **Consist of 4 stages: Most companies follows only the first stage, but precisely.**

QFD's Product Planning house is called the "House of Quality"



HOUSE OF QUALITY

- **Customers express their needs in simple terms.**

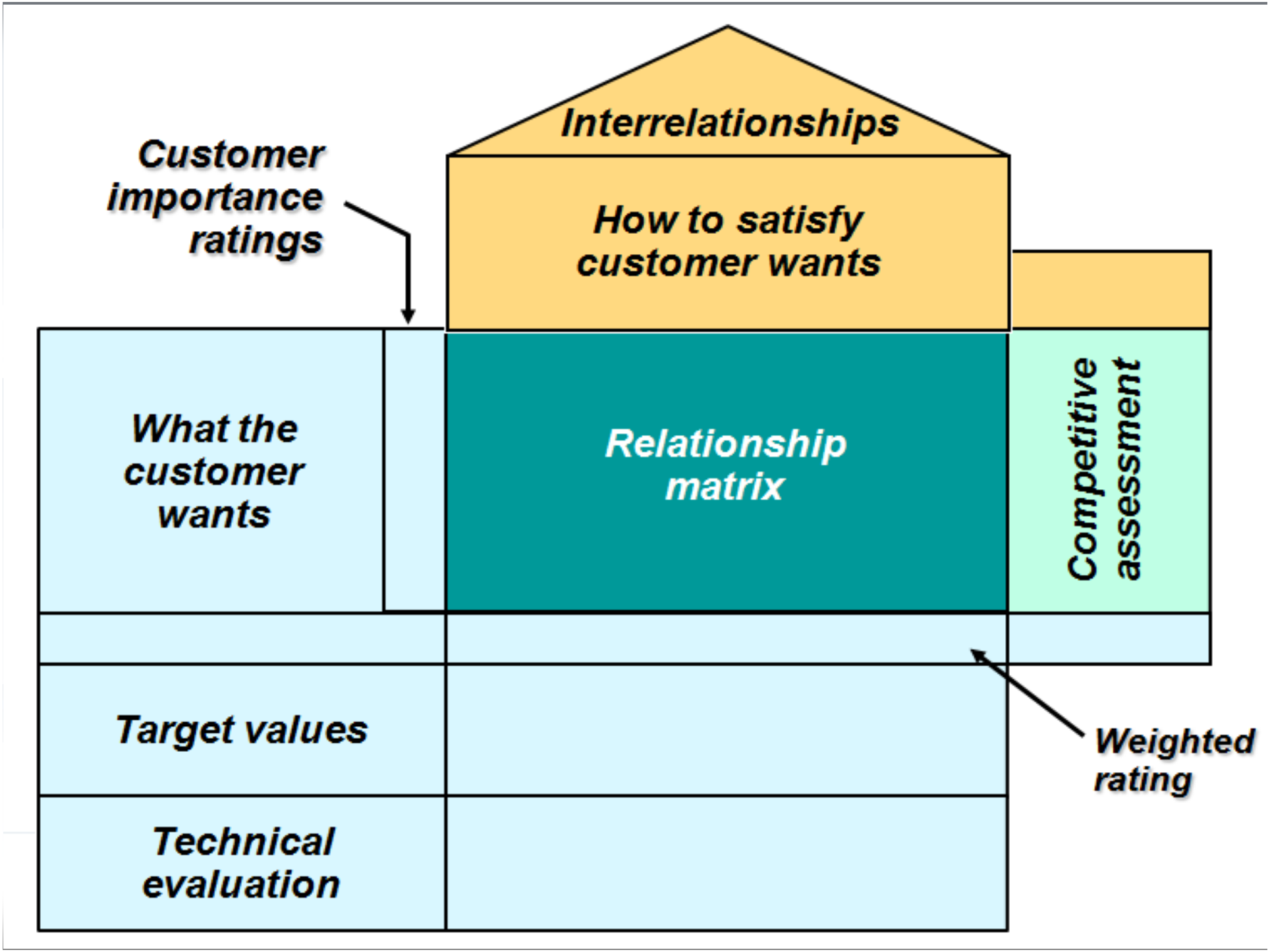
  "I need a handy tool to make smooth holes"

- **For Engineers to work on this it has to be quantified.**

- **Engineers are comfortable with units and quantities.**

- **Conversion of the "user specifications" in to "engineering specification" is important to solve the design problem.**

  http://www.webducate.net/qfd/qfd.html


Interrelationships
Customer importance ratings
How to satisfy customer wants
What the customer wants
Relationship matrix
Competitive assessment
Target values
Weighted rating
Technical evaluation

Evaluation & Choosing a Design – SWOT Analysis

Strengths

Advantages
Capabilities
Resources, Assets, People
Marketing - reach, distribution, awareness

Weaknesses

Lack of competitive strength
Financials
Our vulnerabilities
Timescales, deadlines and pressures
Continuity, supply chain robustness

Opportunities

Market developments
Business and product development

Threats

Environmental effects
Market demand
Obstacles

Design Strengths:

- What are the advantages of the idea?
- How is this idea better than the competitors?
- How are you different from your competitors?

Design Weaknesses:

- Can this idea be made better?
- What does the idea lack in term of experience, team and resources?
- What causes problems or complaints?
- What should be avoided?

Design Opportunities:

What opportunities does the idea have in the market?

Change in market/government policies/global events?

Potential new uses of the product or service from idea.

Design Threats:

What are the obstacles that face the idea?

Do the idea weakness represent any threat to its success?

What is your competitors doing?

Does idea has any features changed which could be a threat to the company?

At the end of SWOT Analysis you should note the following:

- **What must you address immediately?**
- **What can be handled now?**
- **What needs researching further?**
- **What needs to be planned for the future?**

Following data were obtained by conducting market survey regarding a demand for "Good water purifier". Make an objective tree.

1. **Affordable price.**
2. **Safe to operate.**
3. **Easy to operate.**
4. **Can detect chemical imbalance.**
5. **Fewer repairs.**
6. **Easy to repair when needed.**
7. **Long lasting.**
8. **Low or no contamination.**

9. **Takes up least possible space.**
10. **Safe for humans.**
11. **Safe for environment,**
12. **Gets the job done.**
13. **Can correct problems in least time.**
14. **Low maintenance.**
15. **Cleans high volume of water.**
16. **Efficient.**
17. **Provide warm and cold water options.**