Mechanical Analysis and Design
ME 2104

Lecture 7

Specification
Quality – Function Relationship

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

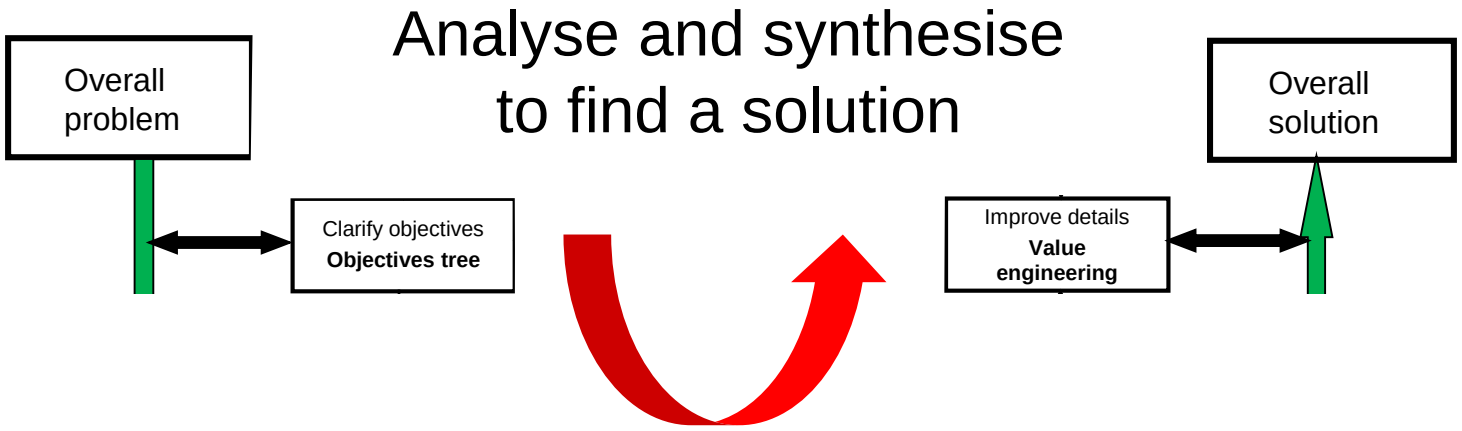
Plan for today

- Team meeting (finish FM, start QFD) (45 min)
- Clarify issues from last week (10 min)
- Lecture (25 min)
  - » Quality - Functional Relationship
- Additional lecture (10 min)
  - » Preparation for 1st project review

Clarify issues from last week

- Team issues:
  - » Reports from Coaches – mixed success???
  - » Management tools (team leaders.,,,)
  - » Coaches are assessing you…
  - » Step by step process…
- Objectives tree
  - » Weighting
- Functional Model
  - » How detailed?

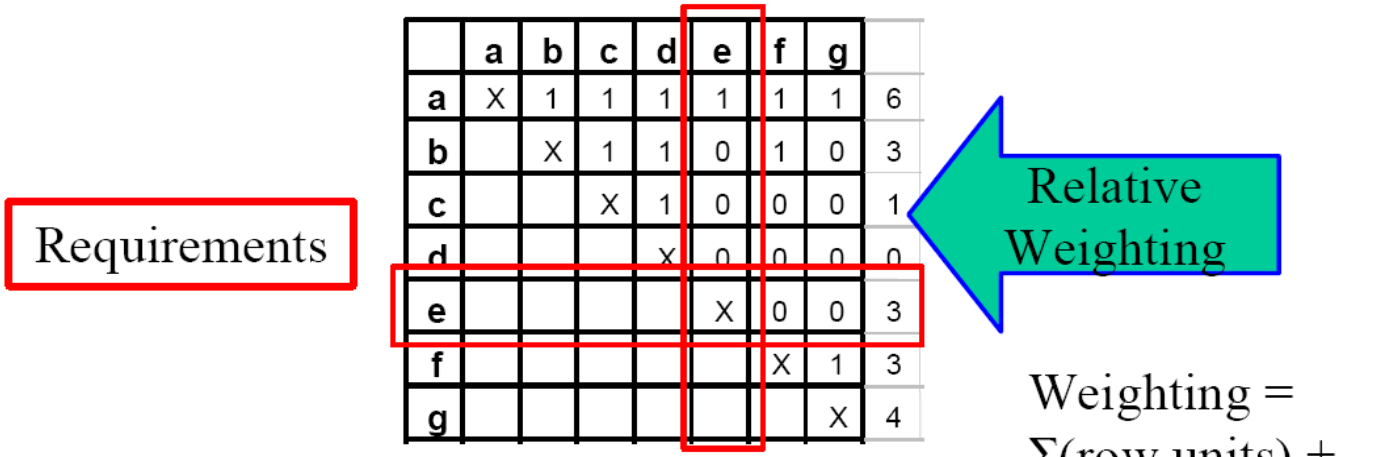
Ways to obtain a solution



Find a solution directly

Objectives tree – weighting

1) Binary weighting matrix



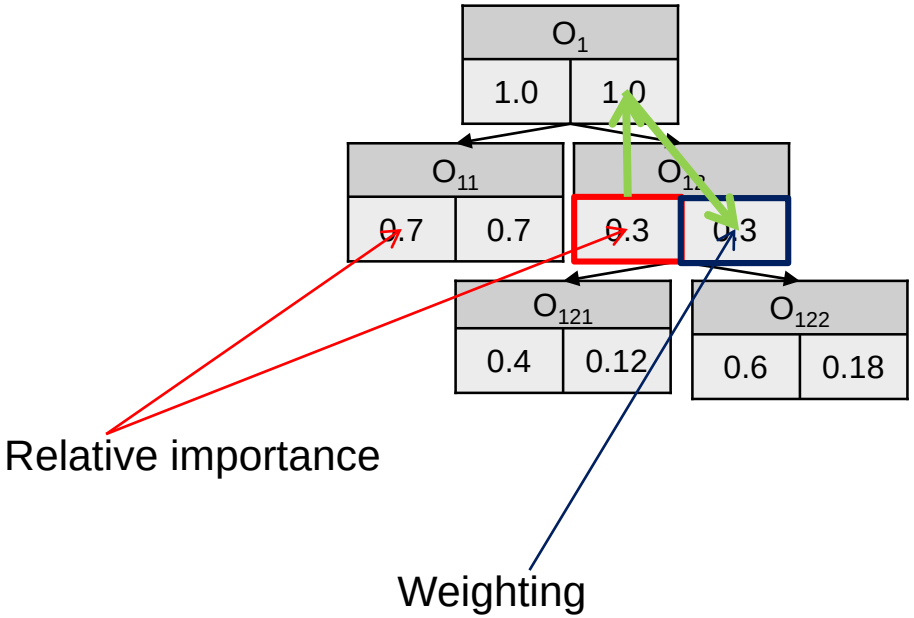
	a	b	c	d	e	f	g	
a	X	1	1	1	1	1	1	6
b		X	1	1	0	1	0	3
c			X	1	0	0	0	1
d				X	0	0	0	0
e					X	0	0	3
f						X	1	3
g							X	4

Weighting =
Σ(row units) +
Σ(column zeros)

Once summed normalise from 1-9

Objectives tree – weighting

2) Relative importance based weighting

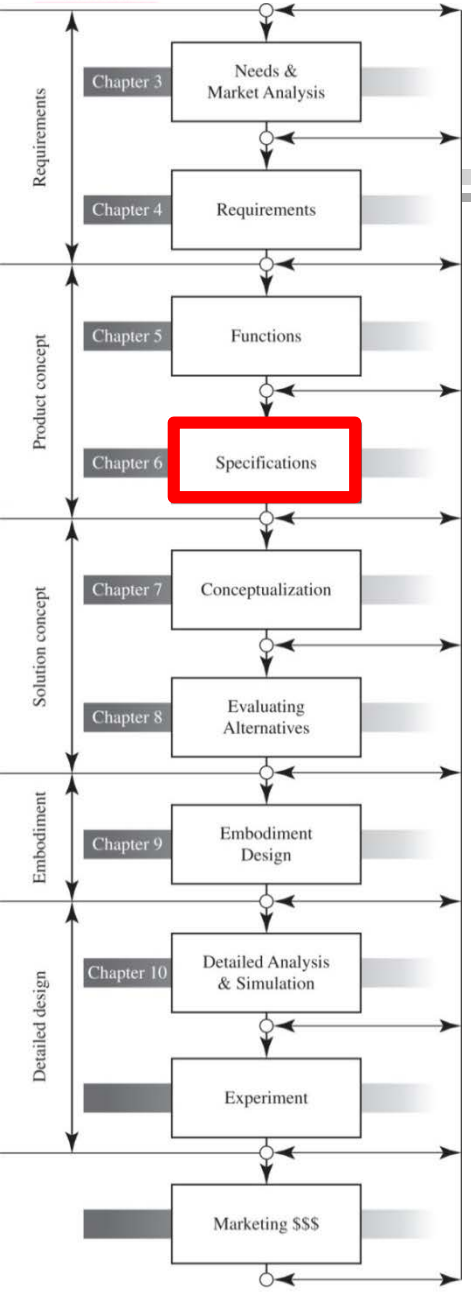


Each level to be normalised from 1-9

Use Level 3 in QFD Matrix

How detailed FM?

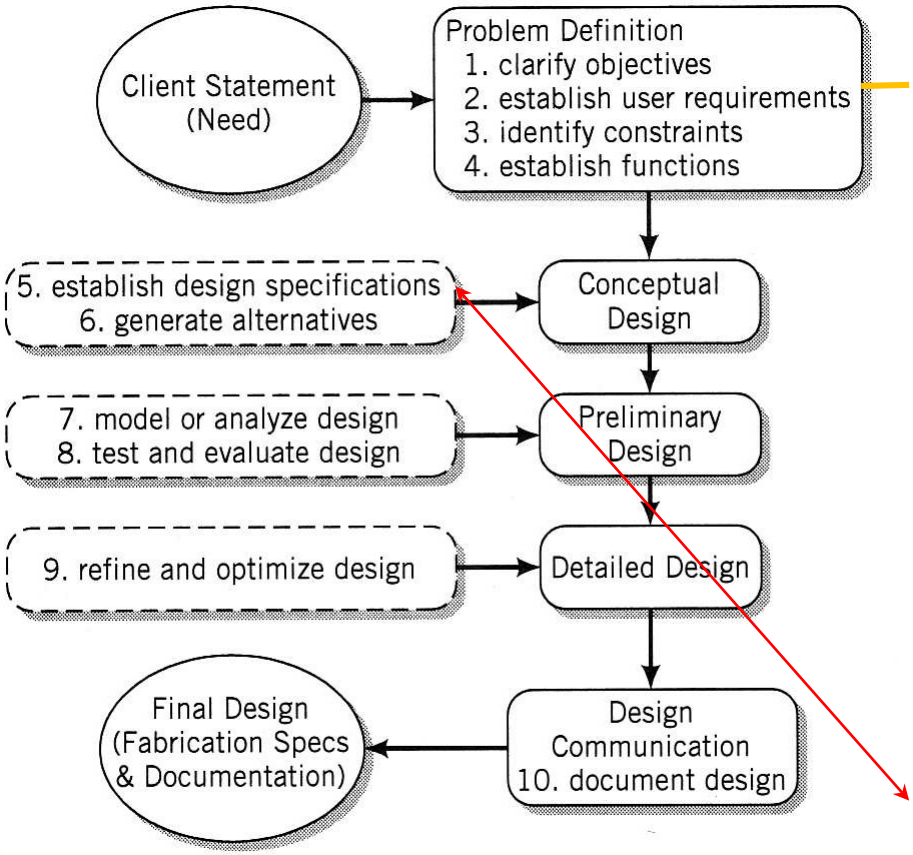
- At least 24 sub-functions
- Main sub-functions are:
  - » Ball storage & loading
  - » Sealing
  - » Aiming
  - » Launching
- The main sub-functions to be detailed in at least 4 sub-functions each…



Specification - Lecture (Part 1)

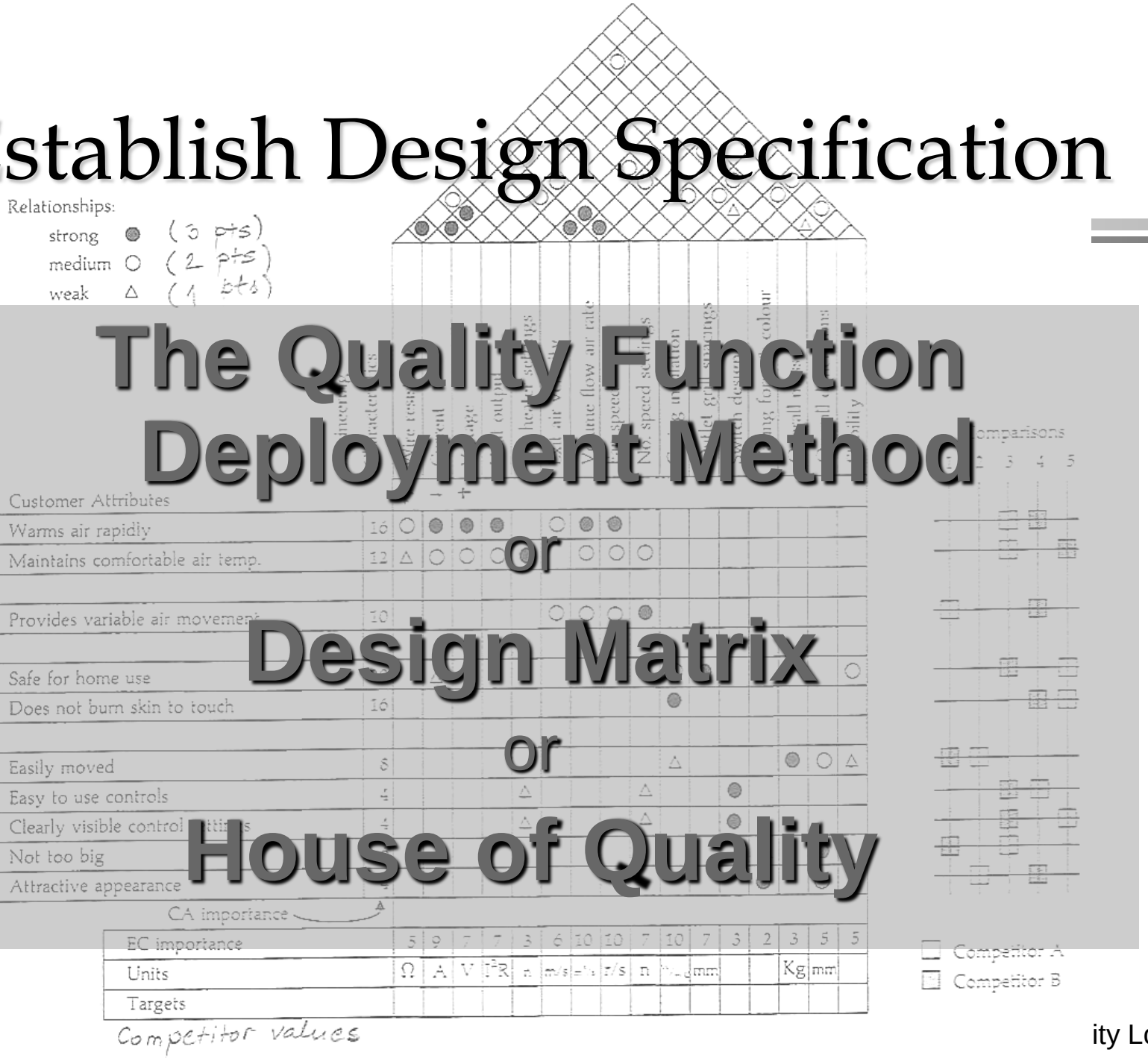
- Engineering Design Process 2nd Edition, Chapter 6
  - » Quantify qualitative objectives
  - » Organize specifications into categories
  - » Further clarify the need statement
  - » A specification consists of a metric and value
    - – Metrics are usually derived from functions (Chapter 5 & Lecture 5)
    - – Specifications can be established using different methods; we will use the 'Performance Specification Method' (Chapter 6, section 6.2 & Lecture 8)

Phase 4: Establish Function



1. Clarify Objectives – The Objectives tree method
   - Prepare list of objectives
   - Order the list
   - Draw the objectives tree
2. Establish user requirements
3. Identify constraints
4. Establish functions
   - Create 'black box' model of the product
   - Break down overall function in sub-functions
   - Connect sub-function chains together
   - Define the system boundaries (Constrains)
5. Establish design specifications
   - Quality-Function deployment
   - Quality-Function matrix (house of quality)
   - Performance specification Method
   - …

Establish Design Specification



The Quality Function Deployment Method

or

Design Matrix

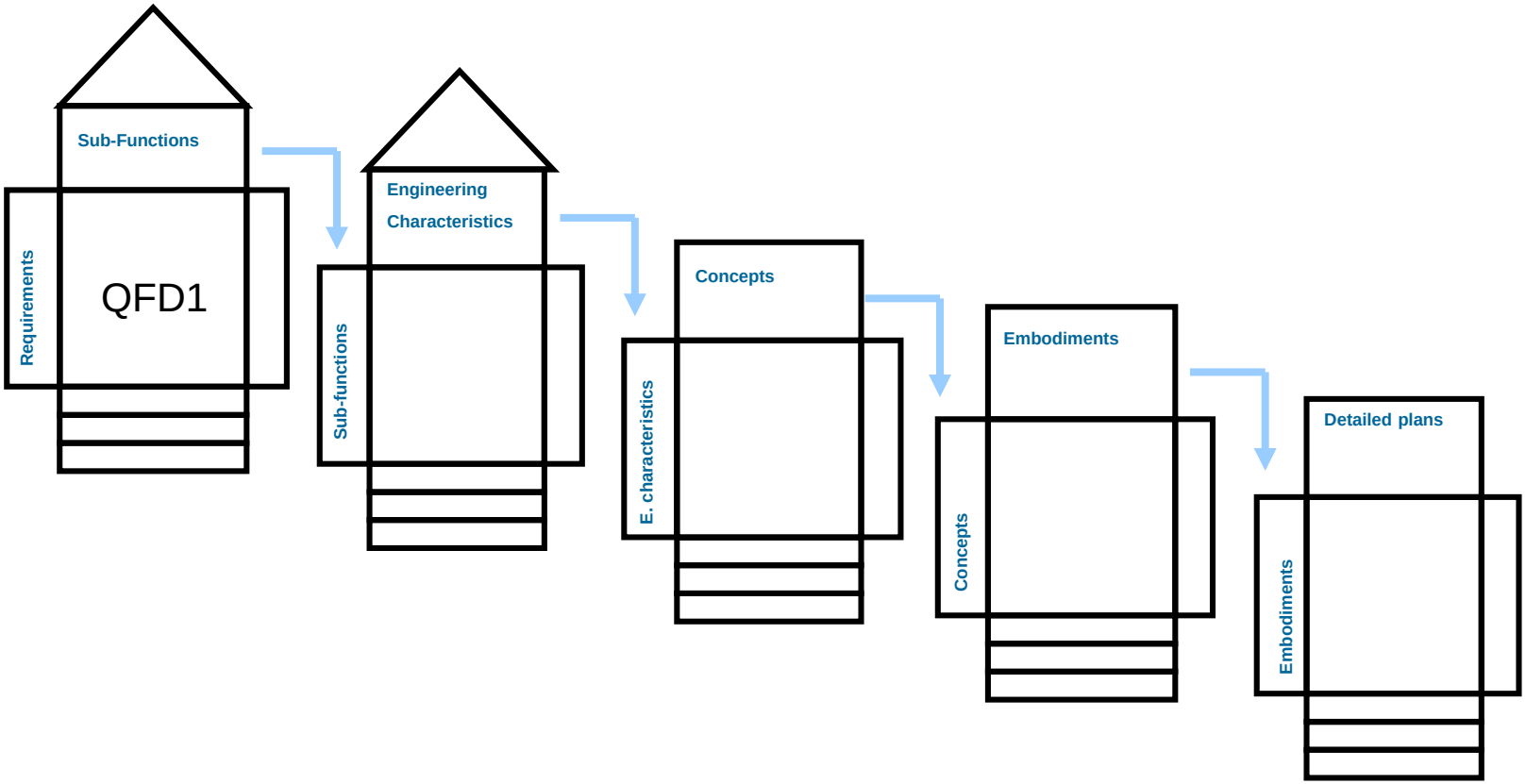
or

House of Quality

Quality Function Deployment

- ***Quality*** (Objectives tree) is defined first
  - » Customer needs and requirements
  - » Desirable product attributes - qualities
- ***Functions*** (Functional model) defined and analysed
  - » Function and sub-functions of product subsystems
  - » Required functions to obtain attributes
- ***Quality-Function Deployment*** (1st QFD) defined
  - » Function and sub-functions of product subsystems required to obtain attributes
- ***Engineering characteristics*** (2nd QFD) defined
  - » Performance, Prescription, Procedure
  - » Developed physical properties - quantities

QFD Charts


Sub-Functions
Requirements
QFD1
Engineering
Characteristics
Sub-functions
Concepts
E. characteristics
Embodiments
Concepts
Detailed plans
Embodiments

Steps in QFD Method

- QFD has background in Japanese design science. Concerned with the translation of customer requirements into engineering characteristics.

1. Identify customer requirements in terms of product attributes,
2. Determine the relative importance of attributes,
3. Evaluate the attributes of competing products,
4. Draw a matrix of product attributes against engineering characteristics,
5. Identify the relationship between engineering characteristics and product attributes,
6. Identify relevant interactions between engineering characteristics,
7. Set target figures to be achieved for the engineering characteristics.

Steps in QFD Method (1)

1. Identify customer requirements in terms of product attributes
   - Customer requirements should not be re-interpreted but only described in terms of product requirements. (Objectives tree)
2. Determine the relative importance of attributes,
   - Rank-ordering methods can be used to help determine the relative weights of each attribute.

To do that systematically compare pair of objectives, one against the other.

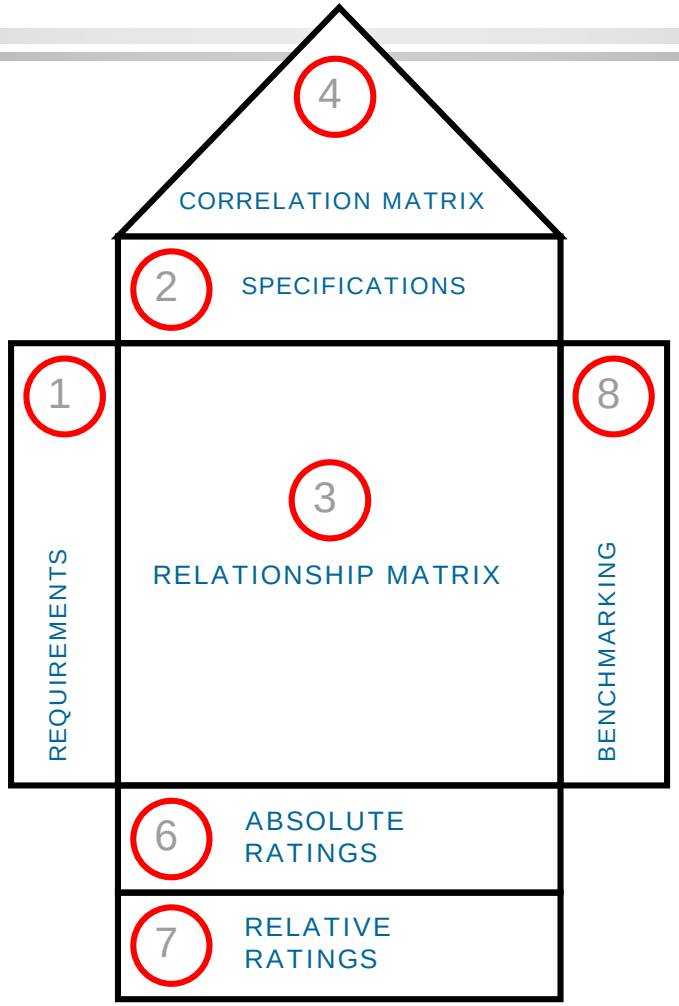
Objectives	A	B	C	D	E	row total
A	-	0	0	0	1	1
B	1	-	1	1	1	4
C	1	0	-	1	1	3
D	1	0	0	-	1	2
E	0	0	0	0	-	0

3. Evaluate the attributes of competing products,
   - Performance scores for competing products and the own product should be listed against the set of customer requirements

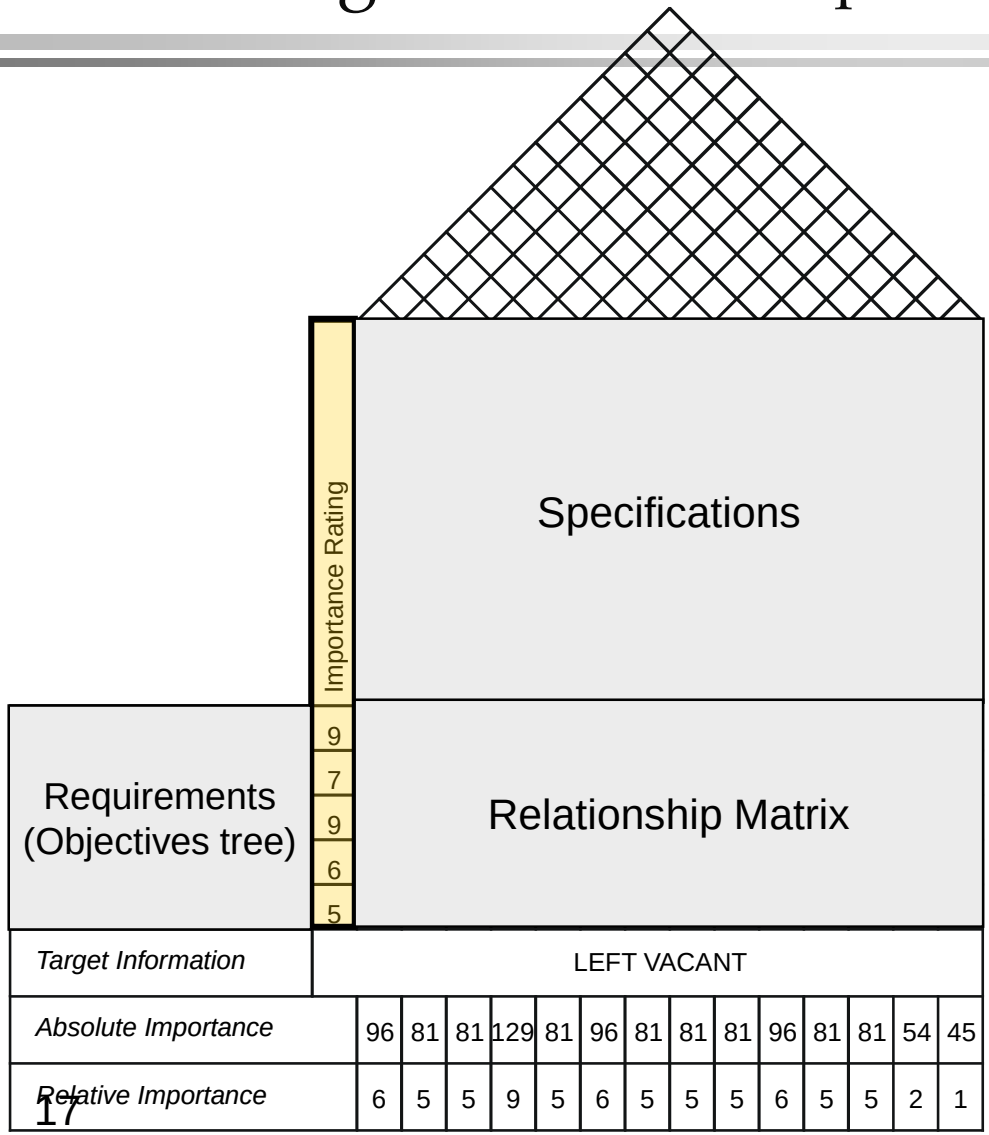
Steps in QFD Method (2)

4. Draw a matrix of product attributes against engineering characteristics,
   - All engineering characteristics that influence any of product attributes should be included and expressed in terms of measurable units.
5. Identify the relationship between engineering characteristics and product attributes,
   - The strength of the relationship can be expressed by numbers or symbols.
6. Identify relevant interactions between engineering characteristics,
   - The roof matrix provides the check and gives an opportunity to recognise strong connections
7. Set target figures to be achieved for the engineering characteristics.
   - These information are obtained from the comparison with competitor products or from trials with customers. These can be set comparative to competitors.

QFD Chart 1 (Specifications & Requirements)

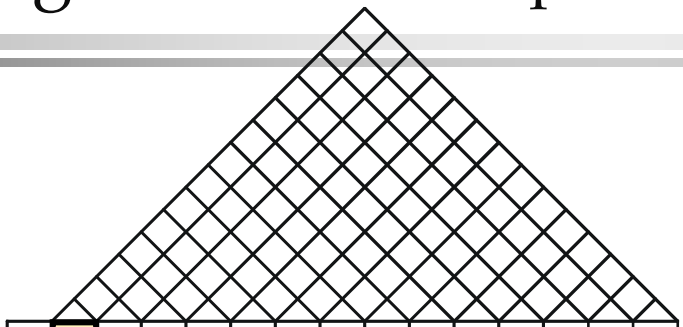


Stage 1 Chart – Requirements & Specifications



- Each requirement is given a rating 1 - 9 (9 is the most important)
  - e.g. if safety is very important it can be rated 9 etc.
- Relationship (correlation) of each specification and each requirement is rated
  - This is to find out how well each specification addresses each requirement.
- Relationships are rated as follows:
  - 0 (or blank) – if there is NO correlation
  - 1 - if there is a slight or weak correlation
  - 3 - if there is medium correlation
  - 9 - if there is high/strong correlation

Stage 1 Chart – Requirements & Specifications

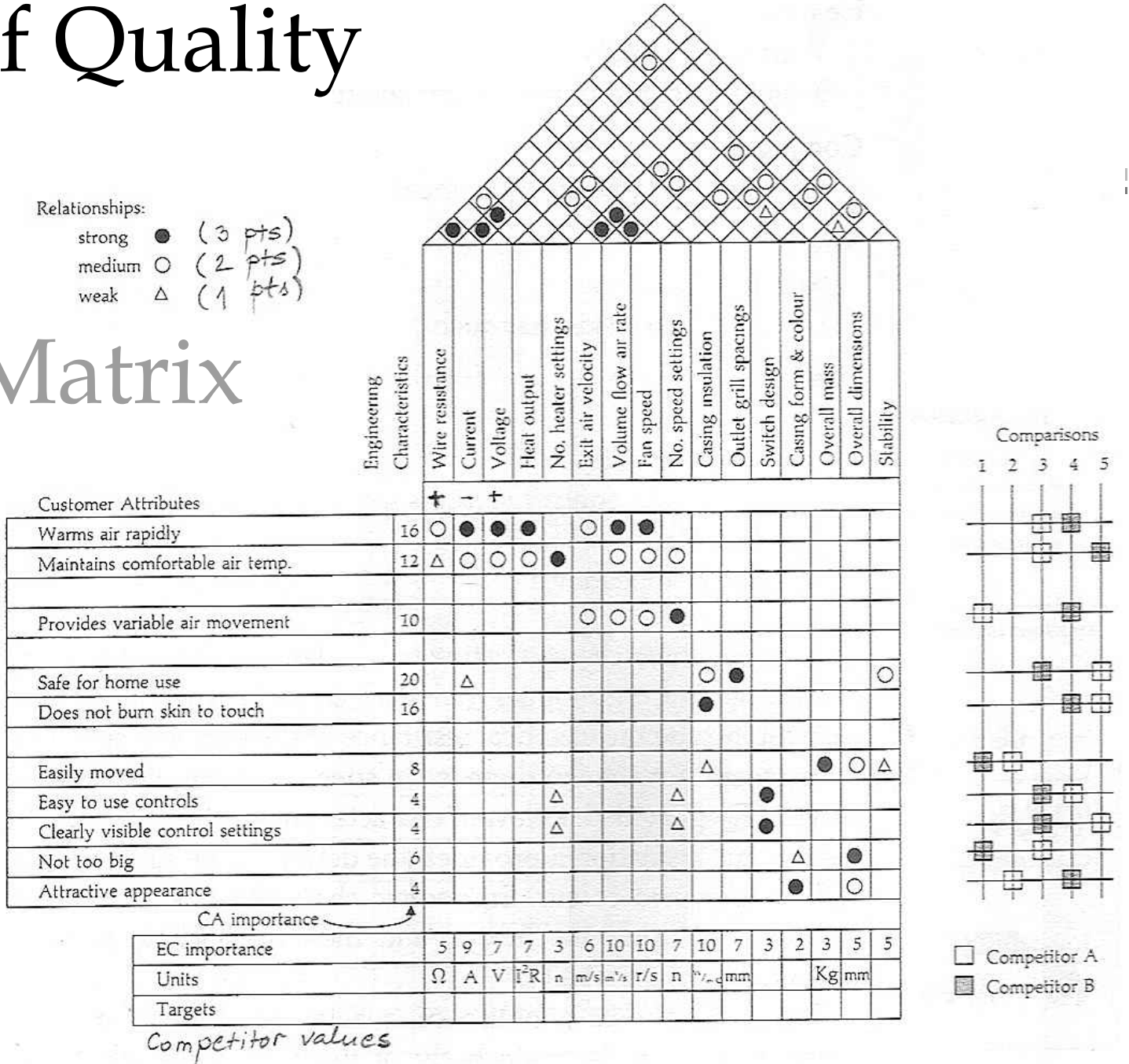


	Importance Rating	Provide seat area	Provide Strength (seat)	Provide comfort to buttocks	Support seat	Provide saet height	Provide hand rest area	Support hand rest	Provide Strength (H.R.)	Provide height to (H.R.)	Provide back rest area	Provide strength (B.R.)	Provide height (B.R.)	Provide Manouverability	Provide pleasing appearance
Seat to rest in comfort	9	9	9	9	9	9									
Support to back	7				3						9	9	9		
Support for hand rest	9				3		9	9	9	9					
Easy to move around	6													9	
Pleasing appearance	5	3					3				3				9
Target Information	LEFT VACANT														
Absolute Importance		96	81	81	129	81	96	81	81	81	96	81	81	54	45
Relative Importance		6	5	5	9	5	6	5	5	5	6	5	5	2	1

- Multiply each specification rating by it's corresponding requirement importance rating and add up the column to get the absolute importance rating.
- Eg for the first specification (Provide seat area):
- (9 x 9) + (3 x 5) = 96
- The highest absolute rating becomes the benchmark value and is given a relative importance of 9. All other specifications are then weighted to this value.
- E.g. 129 is the maximum value - becomes 9
- For 1st specification 96/129 x 9 = 6 rounded down

House of Quality

Design Matrix



Preparation for 1st Project Review

- Report – 10-15 pages, to include all elements of the project and
- PPT – Clear, large fonts, not much text
- 30th October @ 11,00am in AG21 – Groups 1-5
- 3rd November @ 10,00am in ELG01 – Groups 6-9
  - » Please be in room on time ready for presentation
  - » Order: Team 1, 2, 3, … , 6,7,…
  - » Entire group to step in front… but not all need to present…

Deliverables for Phase 1 (Vision and Concept)

Report (Moodle): 29th October @ 17:00 – Word and pdf

Presentation: G1-5 30th October AG21 @ 11:00 – PPT+ Notebook

G6-9 3rd November ELG01@11:00 – PPT+ Notebook

Team management:

- Working agreement
- Team Branding and Logo
- WBS
- Team calendar
- Gantt chart
- **Group Notebook**

Requirements:

- Figure of Merit analysis
- Budget, very short Introduction
- Market Research
- Client Statement/Constraint
- Objective Tree and Weightings
- **Preliminary Requirements List**

Function:

- Black Box - Functional Model
- **Full Actual Functional Model**
- Preliminary Parameter Analysis

QFD1:

- Competitors analysis
- Weighting of the Objectives
- Importance of Functions
- Projectile motion and pressure calc.
- Morphological Chart
- Concept Variants
- Team Vision
- Plan for Phase 2 – Embodiment