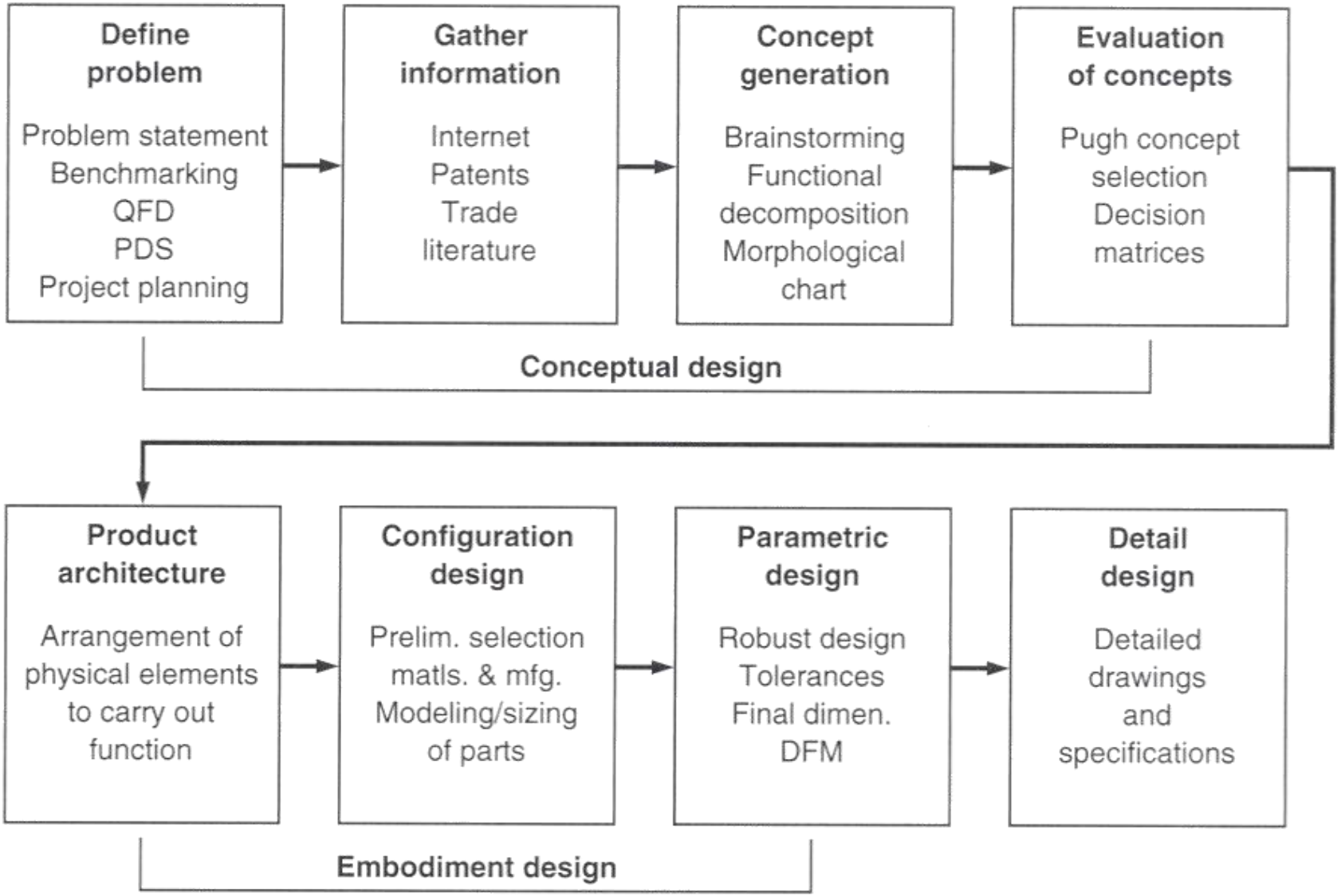
VM450 & VE450

Quality Function Deployment

Outline

- Learn to interpret House of Qualities (HOQ)
- Understand how Customer Requirements (CRs) feed into the HOQ to help identify Engineering Characteristics (ECs) and Product Design Specifications (PDS)
- QFD is method to achieve PDS
- Create drafts of a HOQ for your projects

Product Development Process



QFD and Why

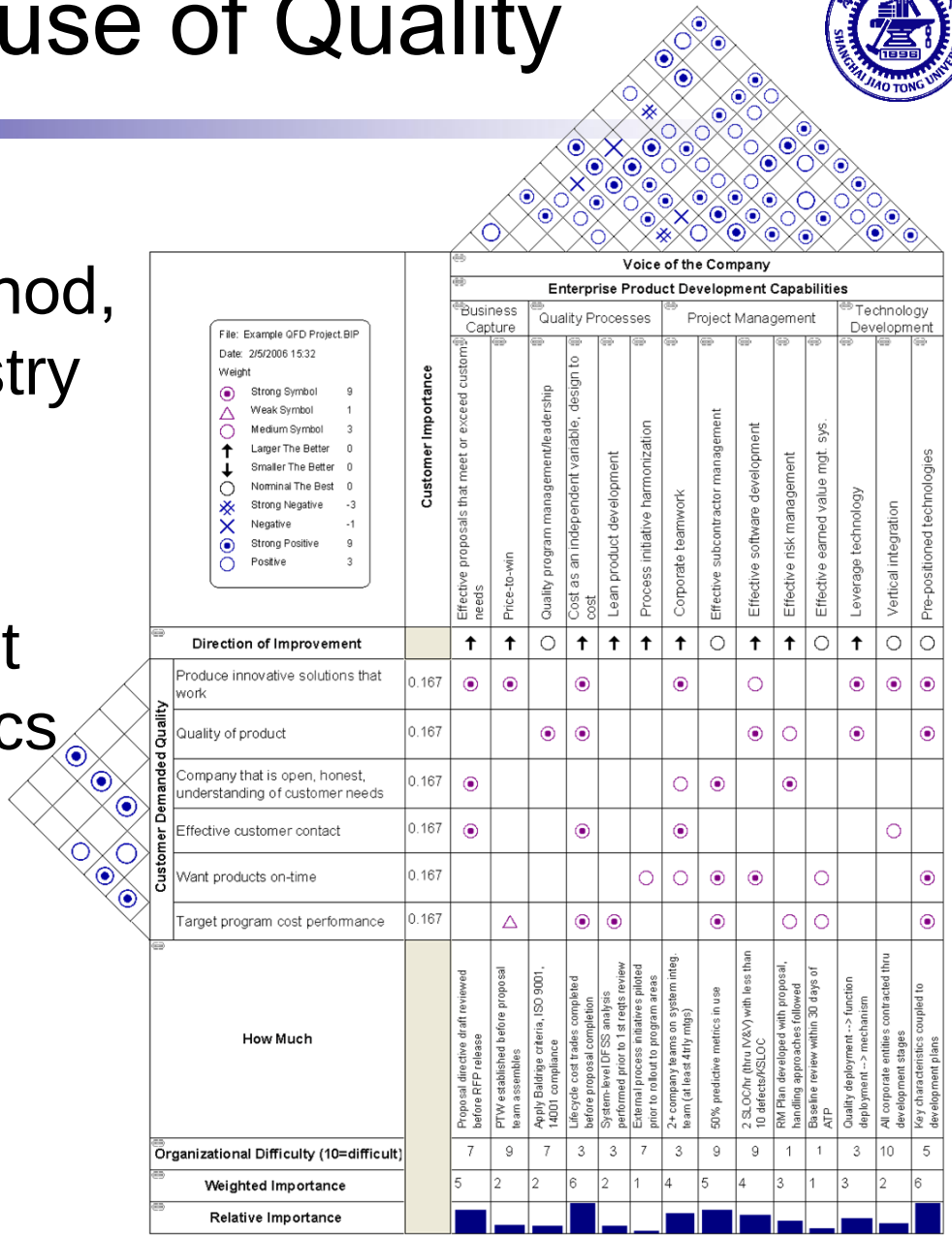
- QFD (Quality Function Deployment) is a "method to *transform user demands into design quality*, to *deploy the functions forming quality*, and to *deploy methods for achieving the design quality* into subsystems and component parts, and ultimately to *specific elements of the manufacturing process*." – John R. Hauser

- You need to bring the "customer's voice" into the product development process for success
  - Customers don't speak in engineering terms
  - Customers don't always articulate their wants

QFD's House of Quality

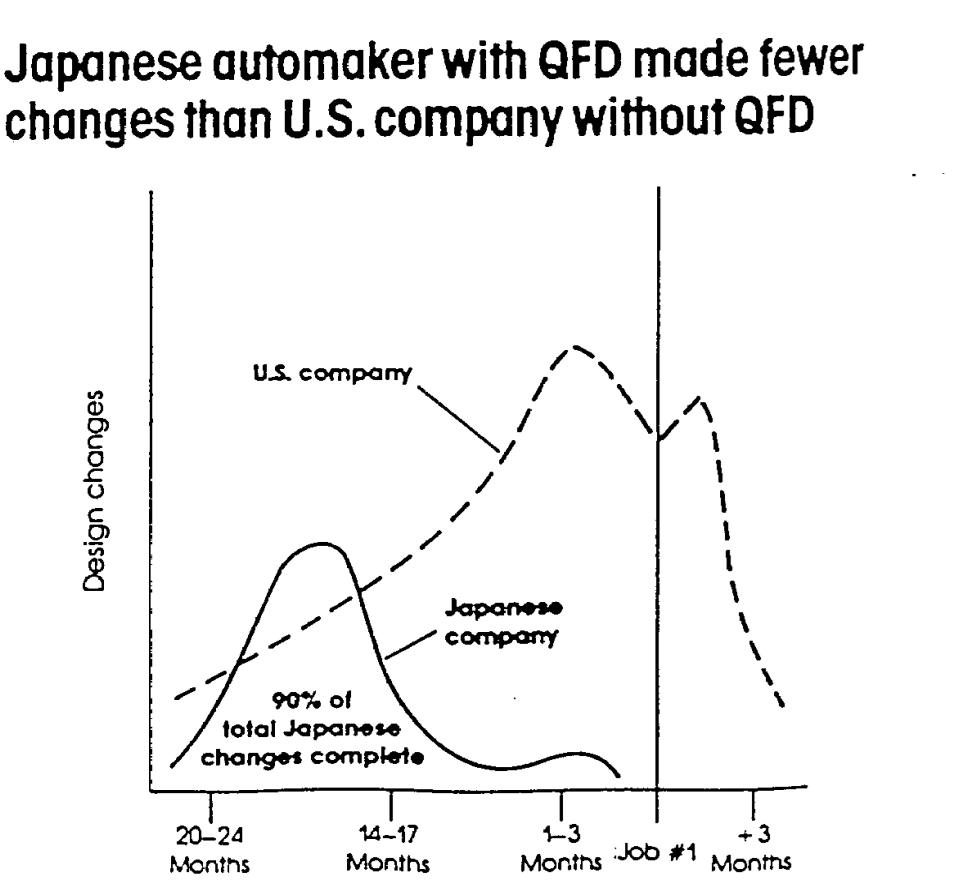
- House of Quality is the QFD's most popular method, most often used by industry

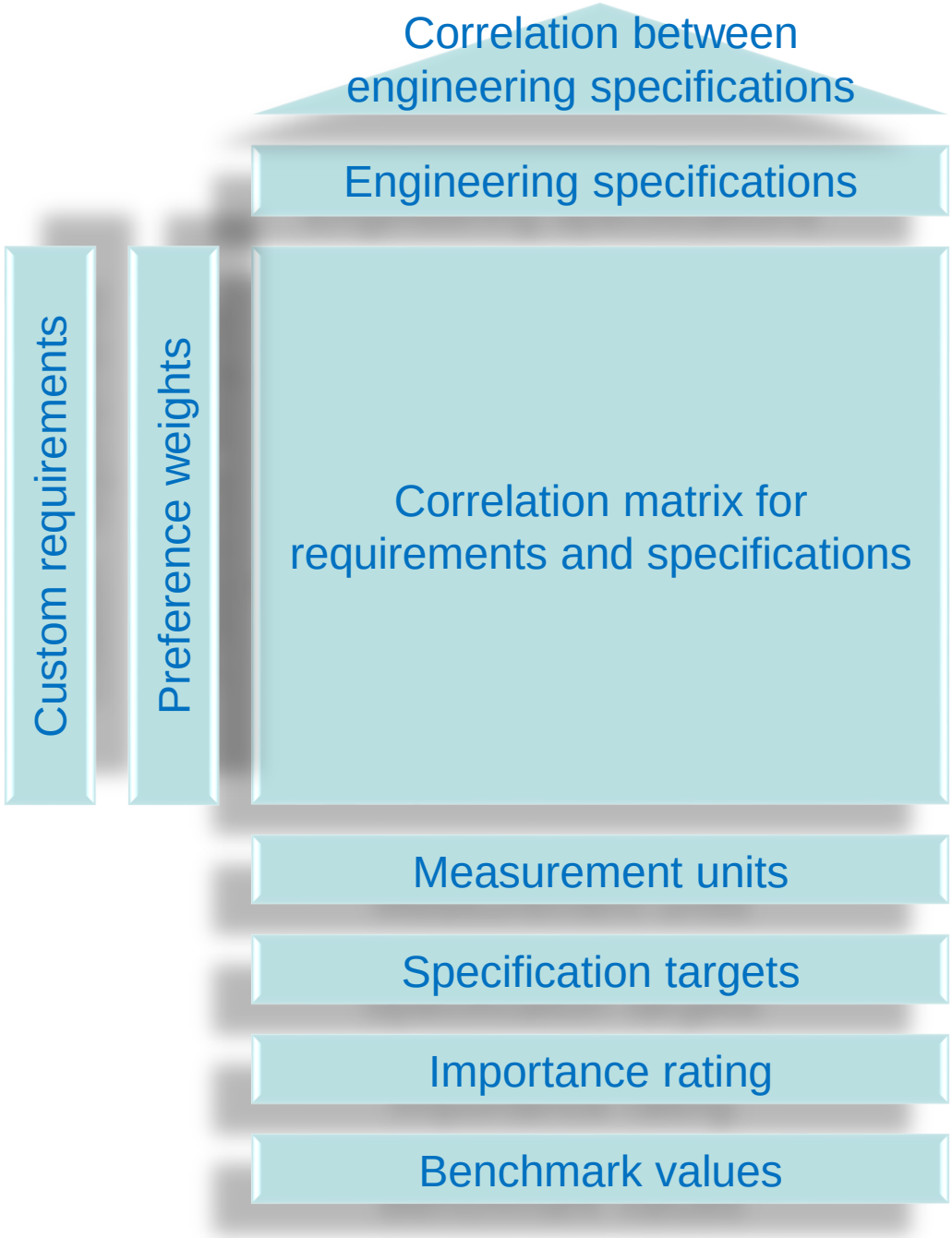
- Conversion of customer requirements into product engineering characteristics



QFD Benefits

- Incorporates the voice of the customer in the designs.
- Prevent getting locked on preconceived concepts before fully understanding it.
- Identify potential challenges to achieve customer requirements.
- Reduce design changes later in the design process




Correlation between engineering specifications
Engineering specifications
Custom requirements
Preference weights
Correlation matrix for requirements and specifications
Benchmark evaluations
Measurement units
Specification targets
Importance rating
Benchmark values

QFD Chart

Example: Automotive Bumper

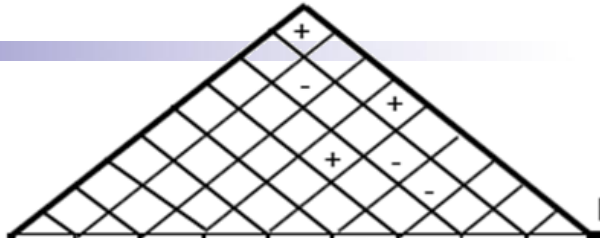
- Looks good
- Holds license plate
- Resists dents
- Protects head lights
- Doesn’t rust
- Last a long time
- Inexpensive
- Protects fender/hood

Engineering Characteristics

- Yield strength [Pa]
- Young's modulus [Pa]
- Mounting hole separation [m]
- Plating thickness [mm]
- Effective spring constant [N/m]
- Cross-section moment of inertia [m^4]
- Weight [kg]
- Maximal deflection [mm]
- Cost [RMB]

Automotive Bumper QFD (Incomplete)

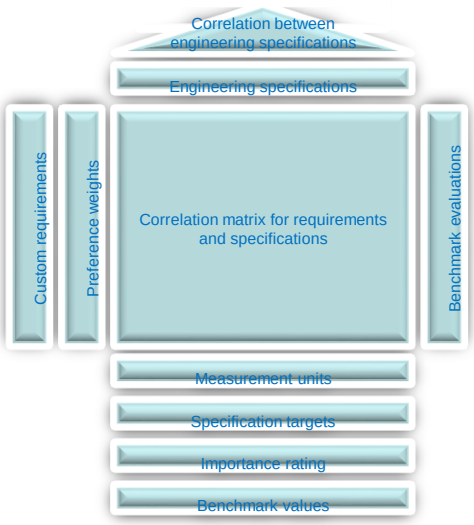
- QFD chart



	Weight (1-10)	yield strength	Young;s modulus	mounting hole separation	plating thickness	effecrive spring constant	cross-section moment of inertia	weight	max. deflection	cost	Benchmark: competitor A	Benchmark: competitor B
looks good	8				9						5	2
holds license plate	5			9					1		4	4
resists dents	7	9	3		1						2	2
protects lights	4	9	9			9	3		9		3	5
doesn't rust	9				9						2	2
lasts a long time	10	1			3						3	4
inexpensive	10	3			3			3		9	1	3
protects fender/hood	4	3	9			9	3		9		3	4
Measurement Unit		psi	psi	in.	in.	lb/in	in.^4	lb	in.	$		
Target Value					0.05			50		100		
Total		####	####	####	####	####	####	####	####	####		
Normalized		0.19	0.12	0.06	0.27	0.09	0.03	0.04	0.10	0.11		
competitor A												
competiotor B												

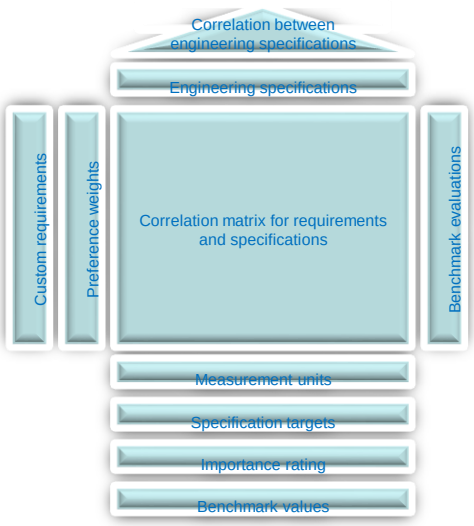
Steps of QFD

- Identify the customers
- Determine customer requirements (CR)
- Determine the weights for CR
- Benchmark the competitions against CR
- Generate engineering specifications (ES)
- Correlate CR to ES
- Importance ratings
- Cross-correlate ES
- Benchmark the competitions against ES
- Set the targets for ES



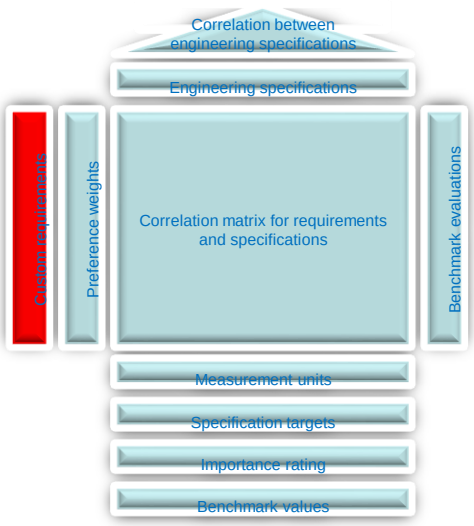
Step 1: Identify Customers

- What is the target market?
- Who is the consumer?
- Who is the user?
- Who will spread the words?



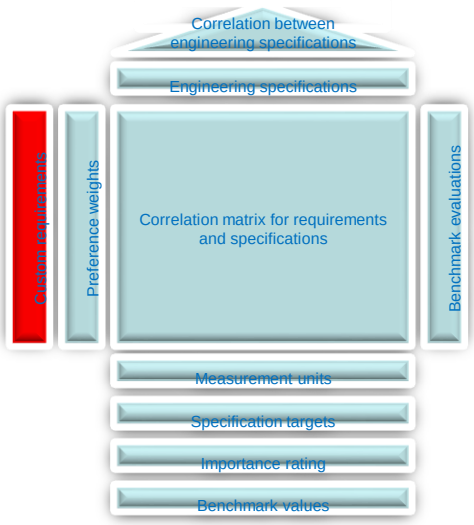
Step 2: Determine CR

- Customer Requirements (CR) can be determined by
  - Customer/market survey
  - Customer/focus group interview
  - Studying products in use



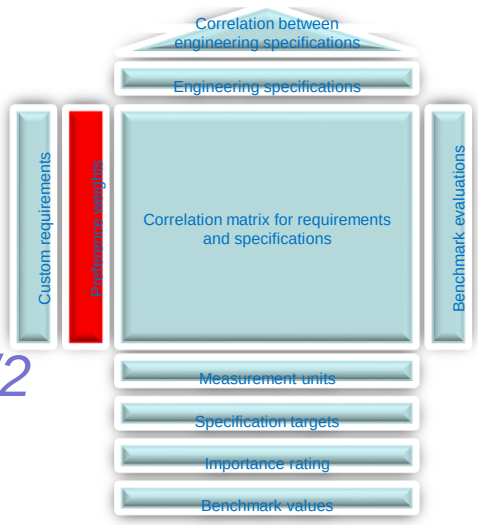
Step 2: Determine CR

- Customer Requirements can be qualitative or quantitative
  - *Function*
  - *Shape/Size*
  - *Appearance/Aesthetic*
  - *Life*
  - *Cost*
  - *Manufacturing/Assembly*
  - *Safety/Environmental*
- Quantitative CR can also be listed as engineering specifications (ES)



Step 3: Determine Weights for CR

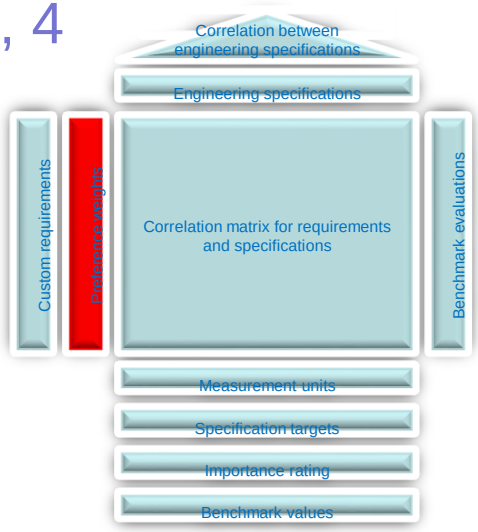
- Different customers have different priorities
  - Rank customers according to importance to you
  - Interview/survey the importance of each CR
  - Direct ranking
  - Binary comparison (yes or no)
    - Make a table with *n* rows for requirements and *n(n-1)/2* columns for comparison scores
    - Compare requirements j^{th} and k^{th}
      - Use a "1" for the more important and a "0" for the less important and fill in the appropriate column
    - Sum across the rows and divide by *n(n-1)/2*



Step 3: Determine Weights for CR

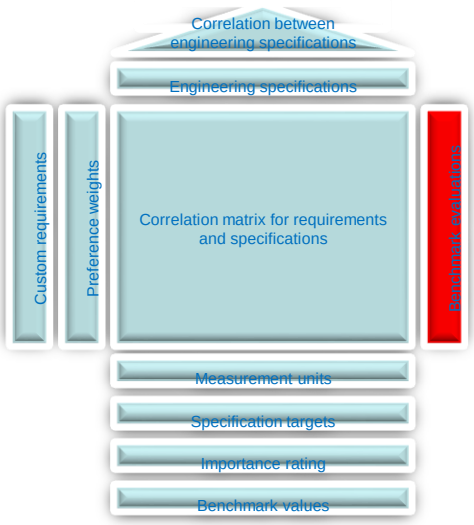
- Different customers have different priorities
  - Rank customers according to importance to you
  - Interview/survey the importance of each CR
  - Direct ranking
  - Binary comparison (yes or no)
    - n = 4 rows, n(n-1)/2 = 6 columns
    - Order of importance: Requirements 3, 1, 2, 4

Requirement 1	1	0	1				2	33%
Requirement 2	0			0	1		1	17%
Requirement 3		1		1		1	3	50%
Requirement 4			0		0	0	0	0%
Total							6	100%



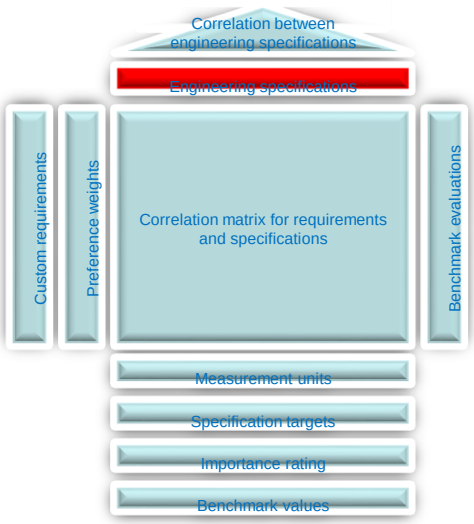
Step 4: Benchmark Competitions against CR

- Identify one or more “benchmark” products that serve identical or similar customer requirements
- Evaluate them against each customer requirement as:
  - 1 = doesn’t satisfy at all
  - 2 = satisfies “slightly”
  - 3 = satisfies “somewhat”
  - 4 = satisfies “mostly”
  - 5 = satisfies perfectly
- Reveals areas for improvements



Step 5: Generate ES

- Engineering Specifications are quantifiable measures that design engineer may specify/control to meet customer requirements
- Must have appropriate units
  - *But values have been set yet at this point.*
- Must cover all customer requirements
- For CR = “durable,” ES can be:
  - Average life to failure (years)
  - Fraction that survive > 10 years (%)
  - Breaking impact (G)
  - Failure load (N)
  - Mean cycles to failure (turns)

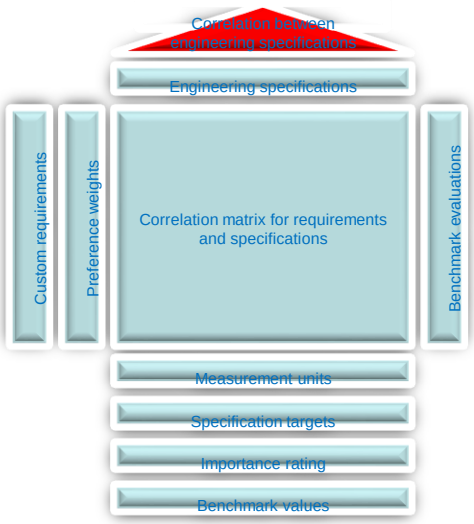


Step 6: Cross Correlate ES

- Changing one engineering specification can affect others

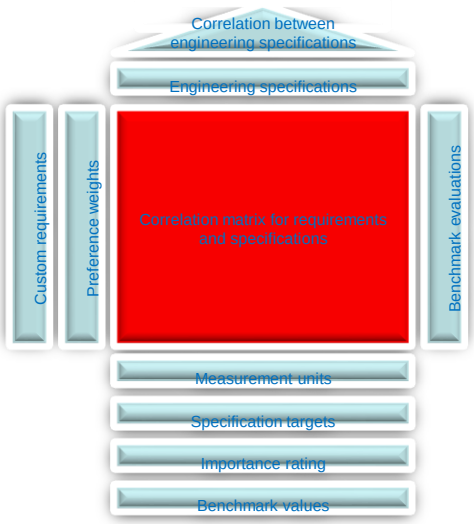
- For each pair of specifications, enter correlation value:
  - ++ = strongly positive
  - + = medium positive
  - - = medium negative
  - -- = strongly negative
  - Blank = totally unrelated

- Reveals potential trade-offs



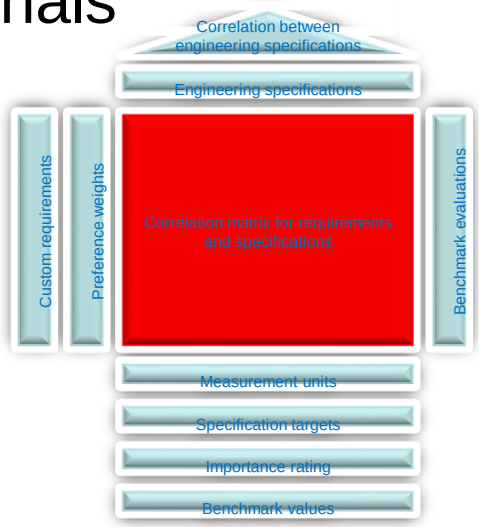
Step 7: Correlate CR to ES

- For each pair of a specification & a requirement, enter correlation value:
  - 9 = strongly related
  - 3 = somewhat related, *where 3 is not a typo*
  - 1 = weakly related
- Reveals CR uncovered by ES
  - Each row (CR) must have at least one “9”
  - Otherwise the CR cannot be satisfied by an ES, must add new ES that is “9” to the CR



Step 7: Correlate CR to ES

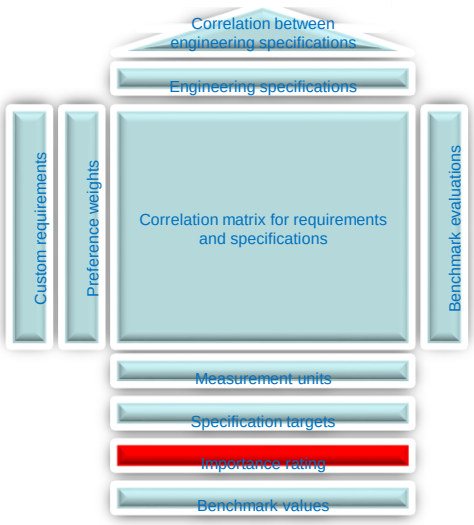
- Reveals CR uncovered by ES
  - An empty row signals that no ESs exist to meet the CR
  - An empty ES column signals that the characteristic is not pertinent to customers.
  - A row without a “strong relationship” to any of the ESs highlights a CR that will be difficult to achieve.
  - An ES column with many relationships signals that it is really a cost, reliability, or safety item that must be always considered.
  - An HOQ displaying a diagonal matrix (1:1 correspondence of CRs to ESs) signals that the ESs may not yet be expressed in the proper terms



Step 8: Importance Rating

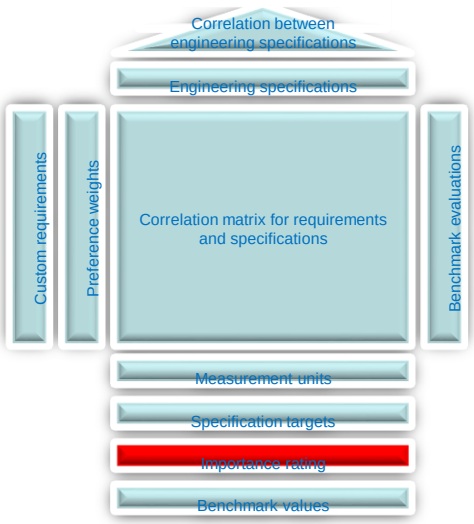
- Based on correlation between CR and ES
  - Absolute Importance is the sum of each column
  - Relative Importance is normalized row above
- ES can be ranked
  - ESs with higher relative importance is CTQ ESs (Critical To Quality)
  - Some CTQ ESs should be treated as constraints.

Hinge stays together	4	3	3			9	3
Waterproof	4	3			3	1	
Absolute Importance		102	130	70	120	111	56
Relative Importance %		17.3	22.1	11.9	20.4	18.8	9.5
Rank Order of ECs		4	1	5	2	3	6



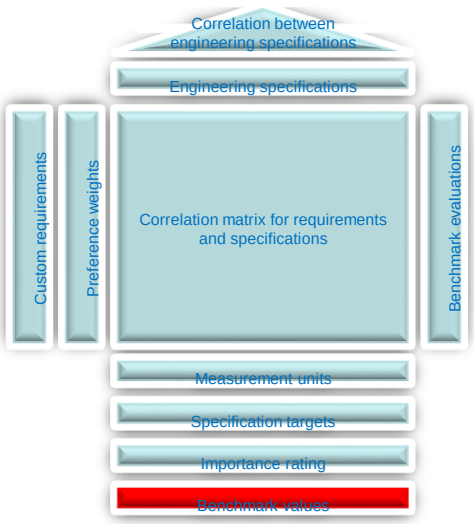
Step 8: Importance Rating

- CTQ ESs are identified from CR Input
  - ESs with the highest ranking
  - Consider if they are really constraints on design feasibility
  - Require designer attention
  - Should become *Selection Criteria* for later evaluating alternative designs
- The lowest-ranking ESs
  - Some design freedom.
  - Can be set to reduce cost or to preserve another design objective
  - If low-ranking ESs are *not correlated to* CTQ ESs, they can be set first



Step 9: Benchmark Competitions Against ES

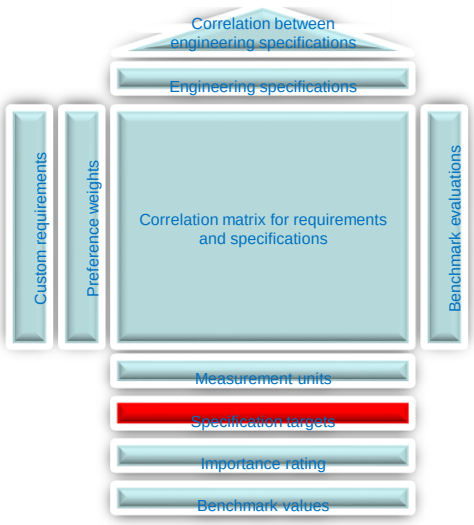
- Enter the performance (*values*) of each benchmark product for each engineering specifications
- May require “reverse engineering” or “informed guess”
- Leave blank if unknowns



Step 10: Set Targets for ES

- Enter targets for each engineering specification as:
  - Specific value
  - Range of values
  - Maximize/minimize

- Pay attention to CTQ ESs
- Be reasonable: can't defy laws of physics, materials properties, economic constraints, etc.
- Be realistic, especially if the state-of-the-art exists



QFD House of Quality: Strengths

- Provides enhanced customer satisfaction
  - Voice of the customer is covered
  - A robust process
- Provides faster responses to market
  - Reduce rework of development
  - Create team agreement and commitment
- Reduces Costs
  - Competitive benchmarking
  - Concurrent engineering
- Increases variety and flexibility

QFD House of Quality: Weakness

- Targets set based on House of Quality alone can be unrealistic
- HOQ's correlation between Engineering Characteristics is inadequate to reflect the tradeoffs correctly
- Difficult coming to consensus
- Demanding and time consuming
- Complexities cause ineffectiveness

Summary

- Transforms qualitative wishes to quantitative goals
- Discourages “diving into design”
- Prevents premature “lock on” to a preconceived concept
- Can be applied to problems and sub-problems
- Suitable for customer-driven product development
- Unsuitable for developing “surprise” products

Acknowledgement
Slides in this presentation are adapted from those provided by Prof. Albert Shih, Department of Mechanical Engineering, University of Michigan, Ann Arbor.