GSOE9820 Engineering Project Management

Week 3
Design Thinking

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PMBOK Guide (6th Ed) Part 1, Sec. 5.2.2.6

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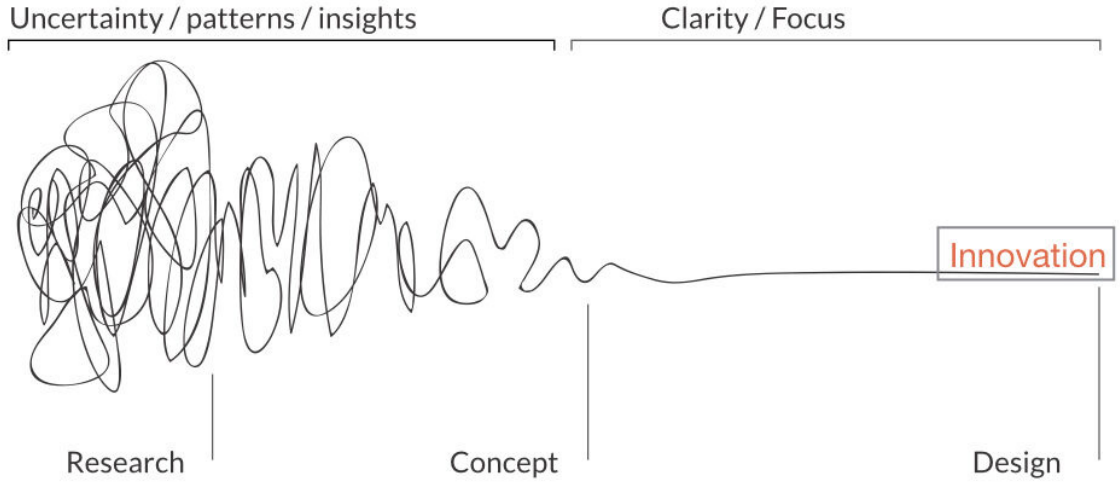
Design Thinking

- A project manager plays an essential role in delivering successful projects to drive business forward.
- Design thinking is a design methodology to achieve effective project management.
- It brings together people's needs with technologically feasibility and economically viability. It can convert customer desires into market values.
- Design thinking is a solution-based approach, not problem-based. Problem-based approach is to make something go away, but design thinking is bringing something into being.
- Design Thinking is to explore human-centred innovative solutions.



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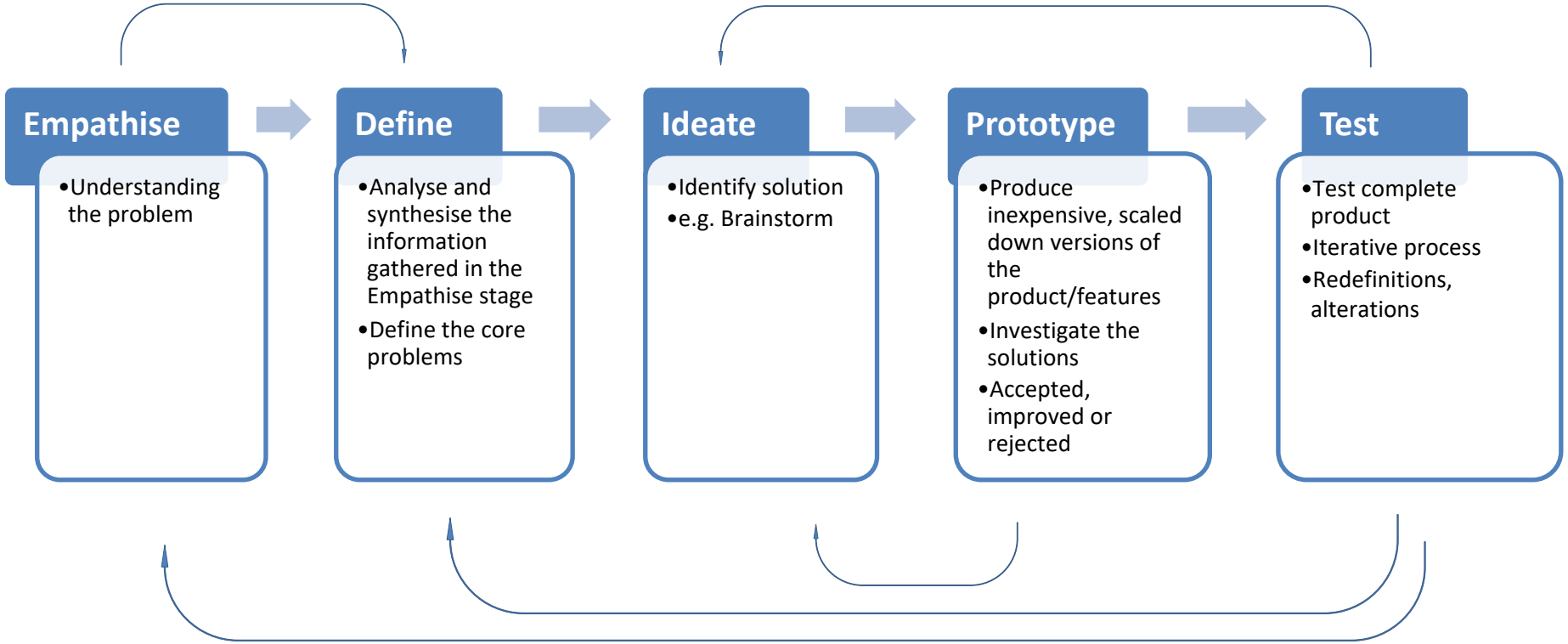
Implementing Design Thinking

- There are 5 stages in the process of design thinking
- Iteration process and not sequential



Implementing Design Thinking

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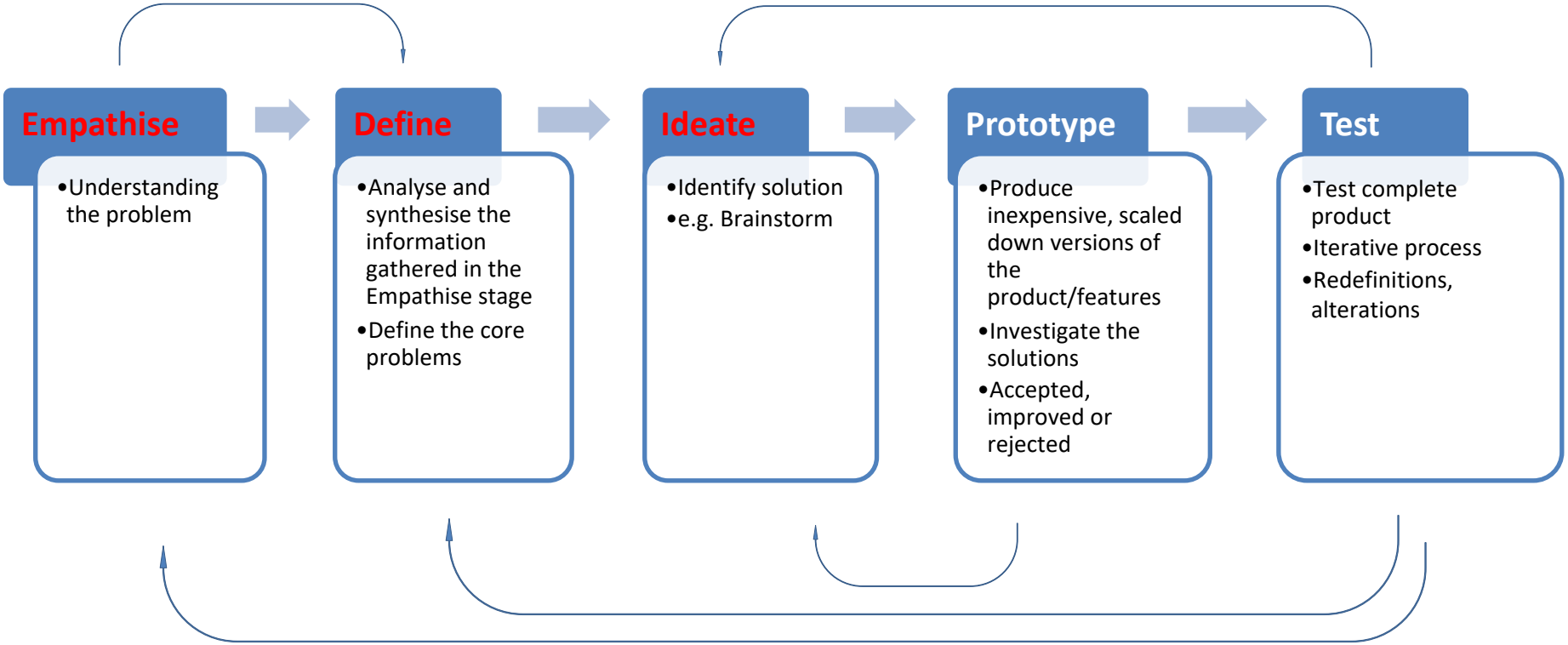
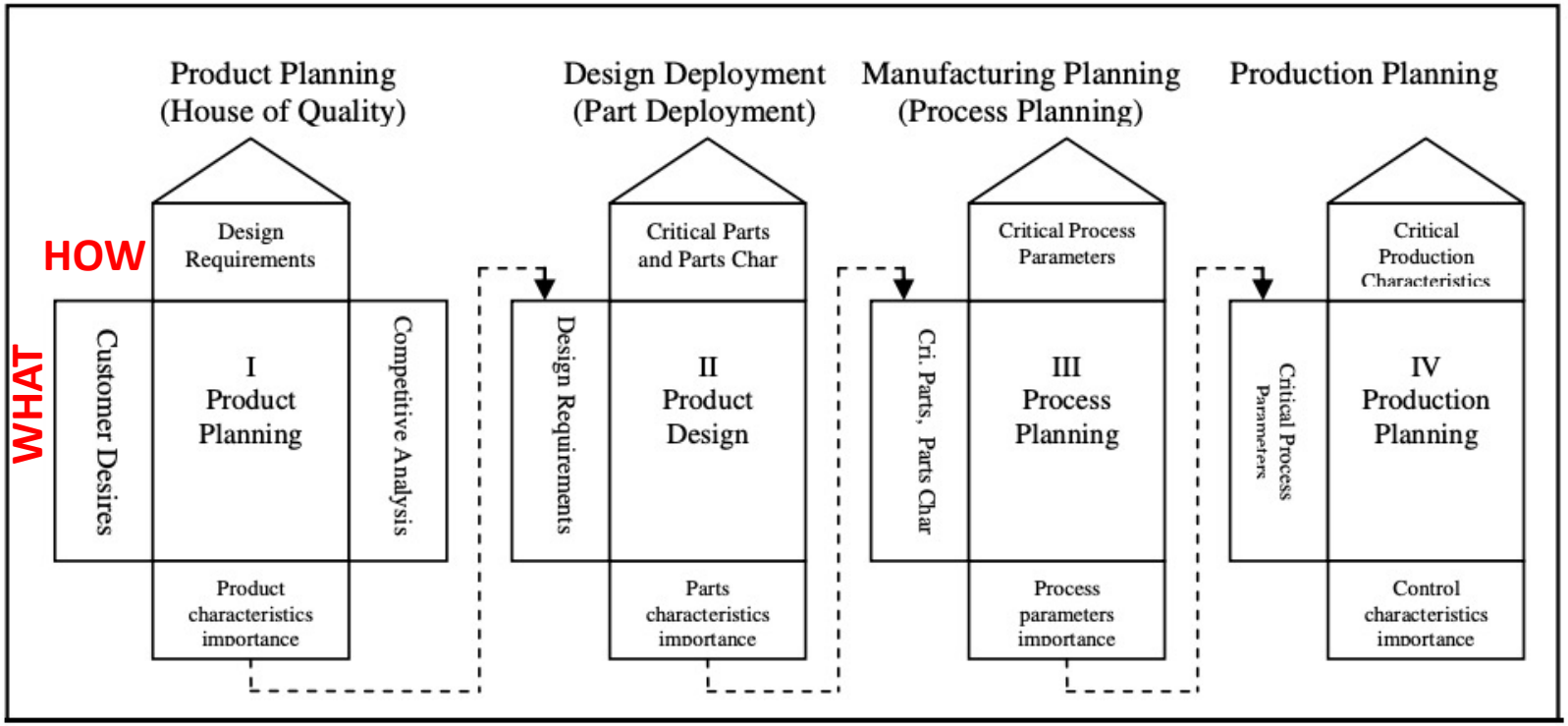


Quality Function Deployment

- Quality Function Deployment (QFD) is developed to translate the customer requirements into engineering parameters of specific products/services.
- Originally developed in Japan by Dr. Yoji Akao and Shigeru Mizuno in 1960s .
- At that time, quality control had been introduced in the Japanese manufacturing industry, but aiming at fixing a problem during or after manufacturing.
- Professor Akao and Mizuno proposed a quality assurance method that would design customer satisfaction into a product before it was manufactured.
- Listen to the “Voice of the customer”, involve customers early.
- QFD aids design engineers and marketing people to answer three essential questions:
  - What really matters to customers in terms of their needs, requirements, and expectations?
  - What design parameters are meaningful to customers needs?
  - What should these parameters target for the new design?

Four Phases of QFD Approach

1. Product planning (House of Quality): design requirements
2. Product design: parts characteristics
3. Process planning: manufacturing requirements
4. Production planning: production requirements



Cohen (1995); Yalcin (2011)

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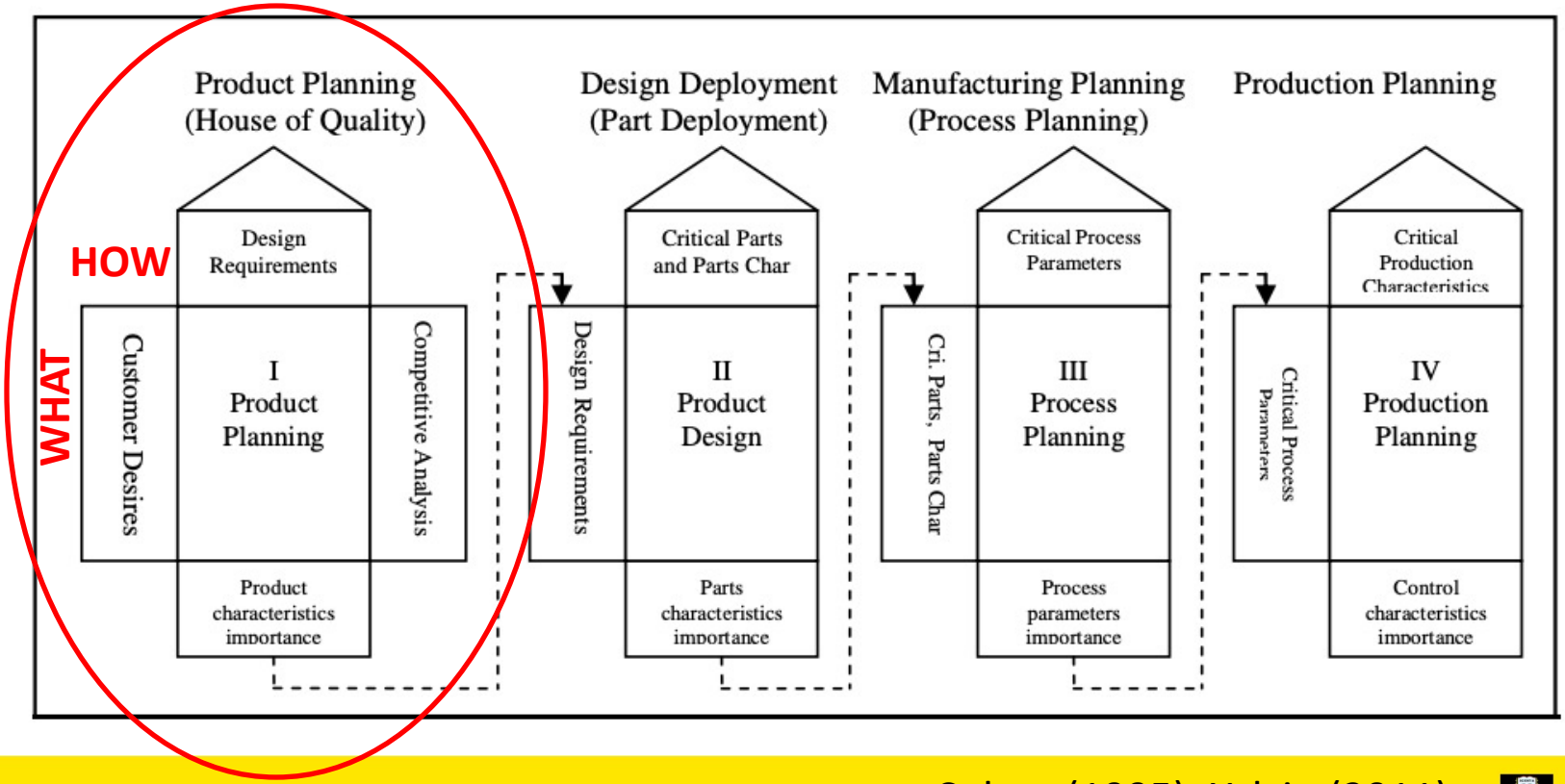
House of Quality

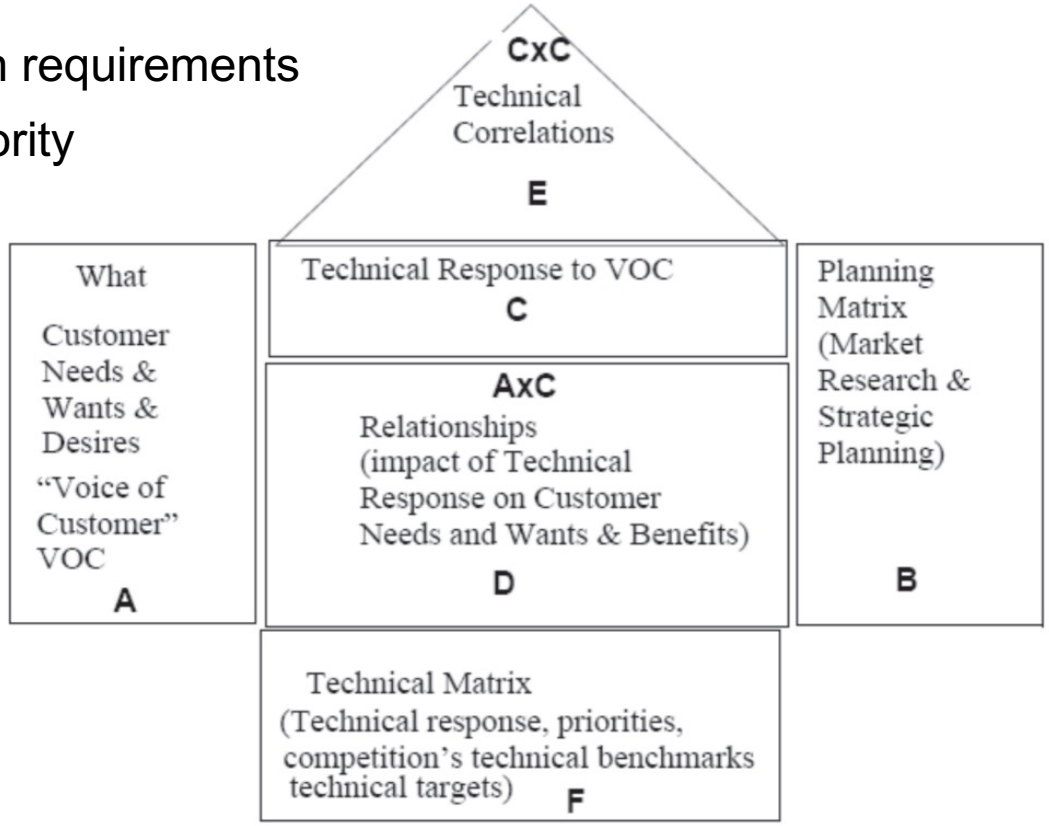
- The starting point of QFD is the establishment of House of Quality matrix
- WHATs: first phase is to collect customer needs for the product
- HOWs: transform these needs into technical measures (or technical requirements, product design specifications, engineering characteristics, performance measures, substitute quality characteristics)



Cohen (1995); Yalcin (2011)

Six Steps to build House of Quality

- Step 1: Customer Requirements (What)
- Step 2: Technical requirements (How)
- Step 3: Relationship between “what” and “how”
- Step 4: Competitive analysis
- Step 5: Interrelationships between requirements
- Step 6: Technical requirement priority



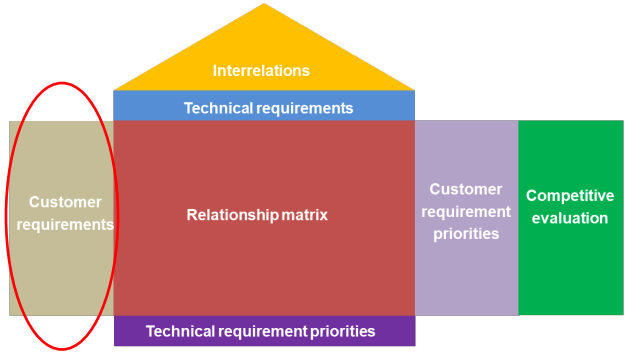
(Gupta&Srivastava, 2011)

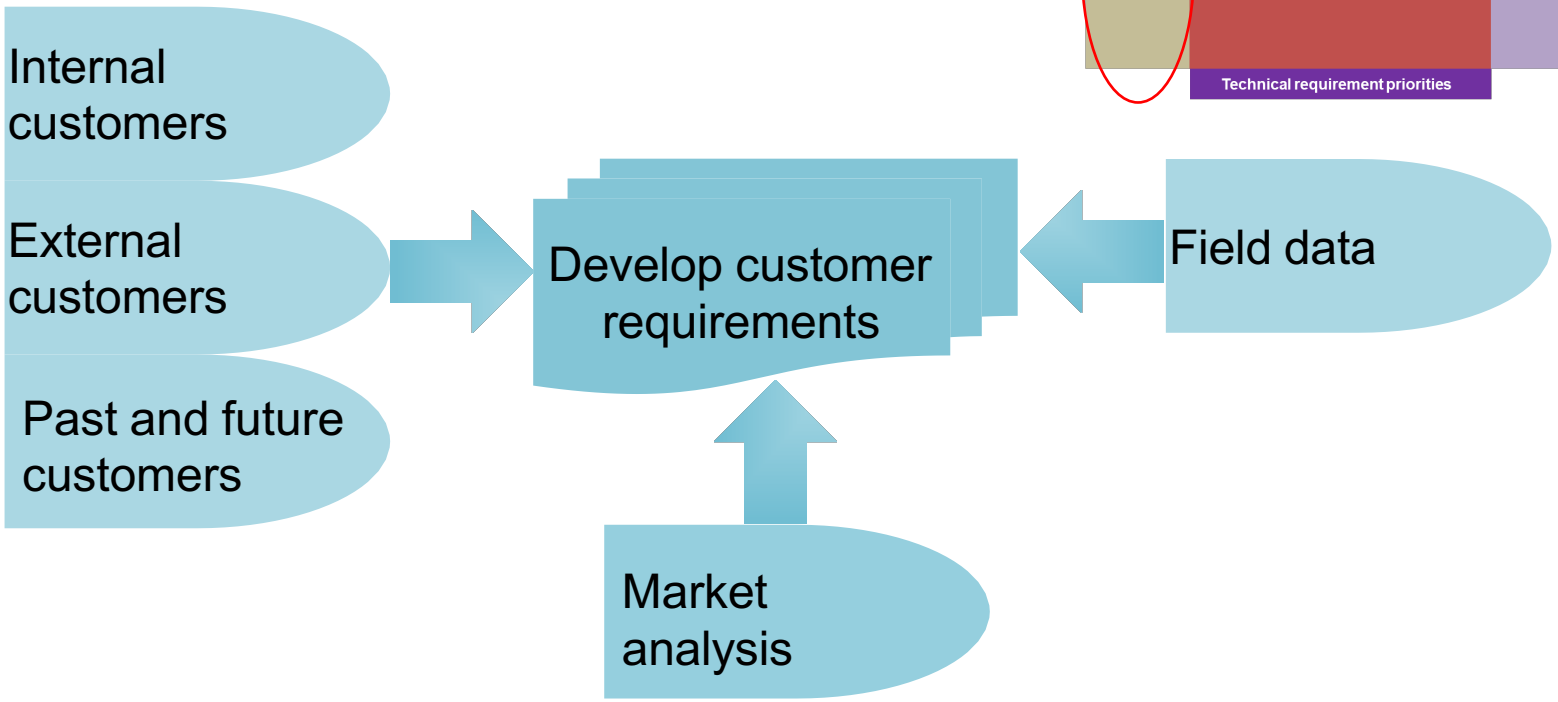
Case study

- Your team is designing a new fridge
- The first action is to construct a House of Quality

Step 1: Customer Requirements (What)

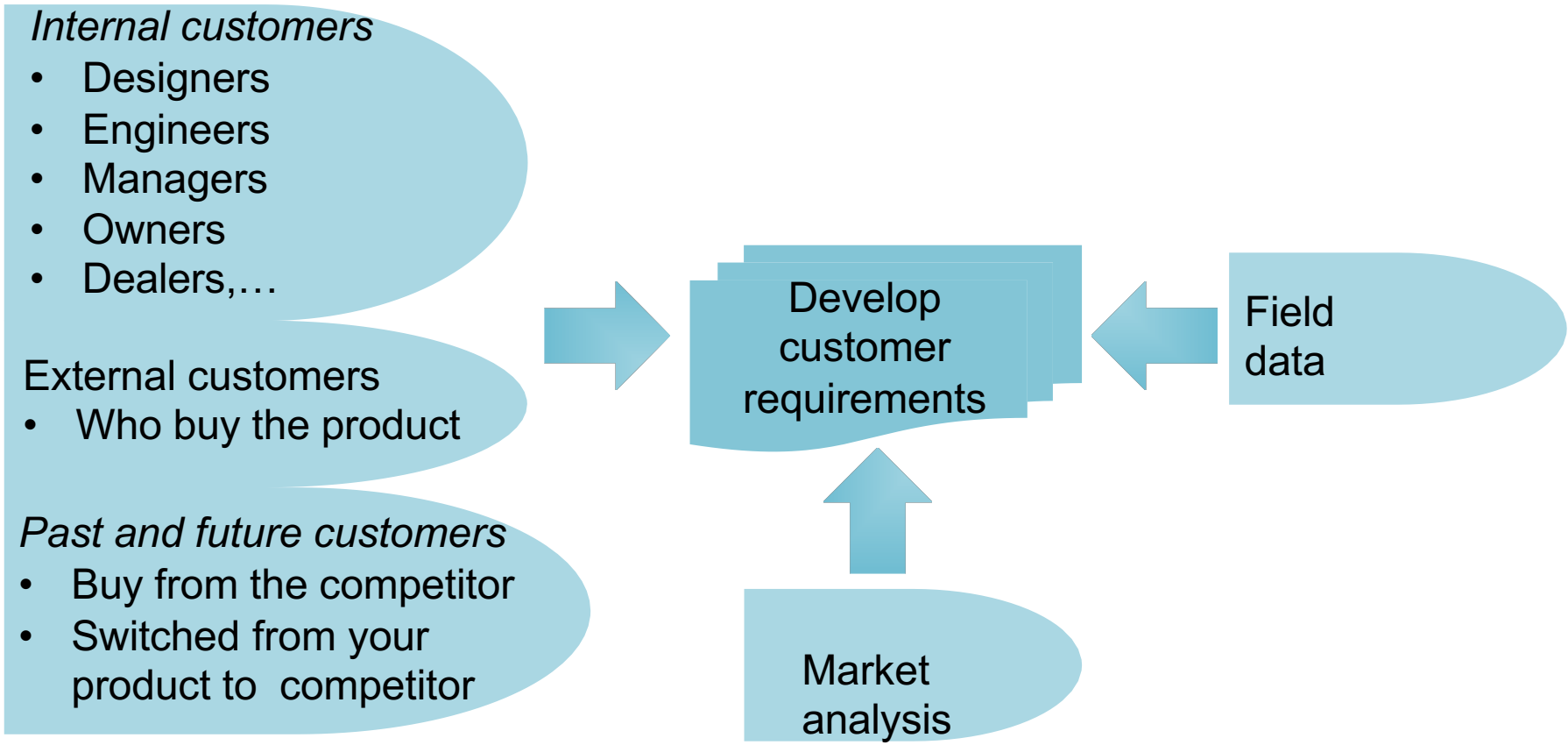
Source of obtaining customers' requirements





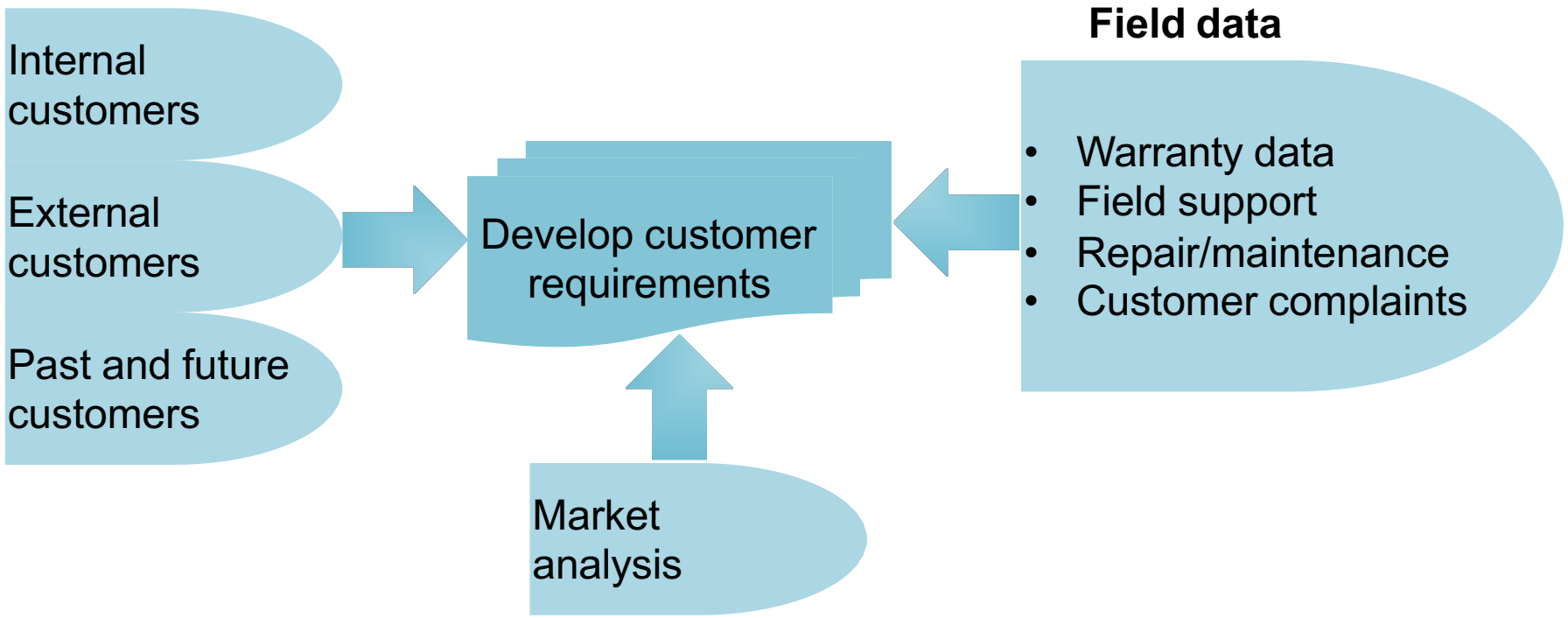
Step 1: Customer Requirements (What)

Source of obtaining customers' requirements



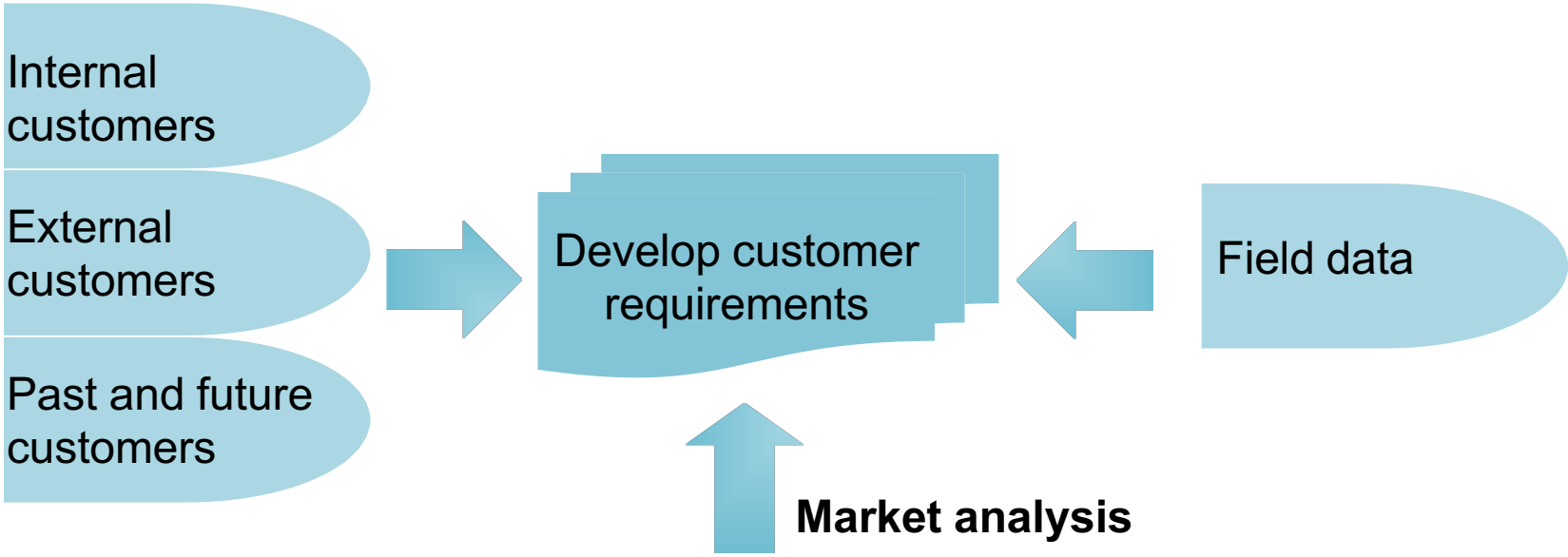
Step 1: Customer Requirements (What)

Source of obtaining customers' requirements



Step 1: Customer Requirements (What)

Source of obtaining customers' requirements



- Questionnaires; Mail, Telephone, ..
- Product clinic: People come and use the product
- Focus group: Groups of 8-12 with facilitator to obtain attributes
- Personal observations: Customers observed while using product
- Individual interview
- Listening in dealerships
- Marketing surveys

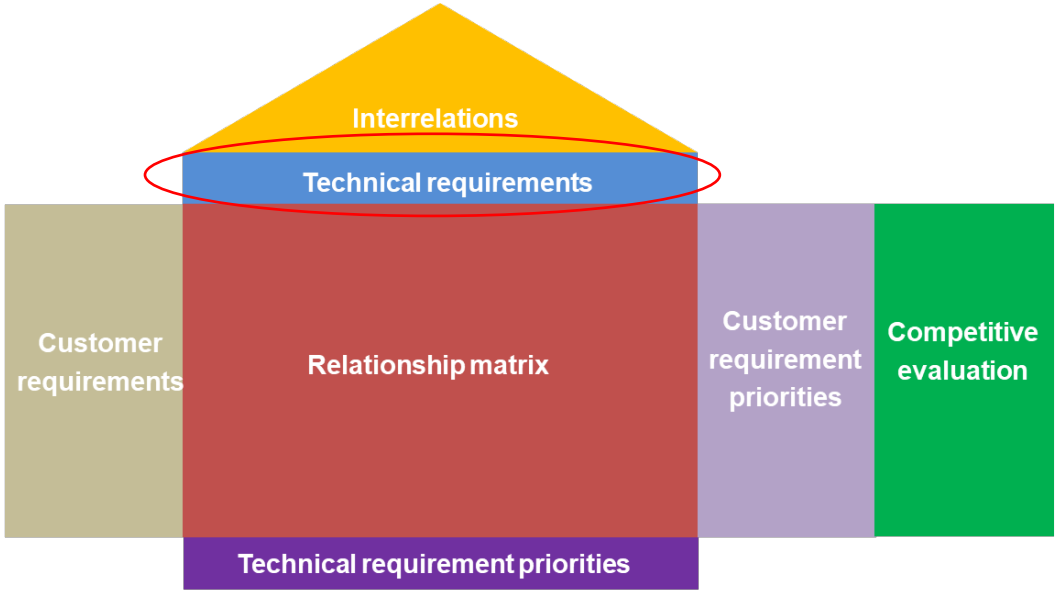
Step 1: Customer Requirements (What)

- What customers want?

Customer requirements
Long-time freshness of food
High star rating
Large internal space
Well space organisation
No frost
Long warranty period
More smart functions (e.g. displays)
Quiet
Low price

Step 2: Technical requirements (How)

- Translation of customer requirements to technical/engineering performance measures, engineering parameters
- At least one engineering parameter should be defined for each customer requirement
- Number of engineering parameters should not be too many (< 30)



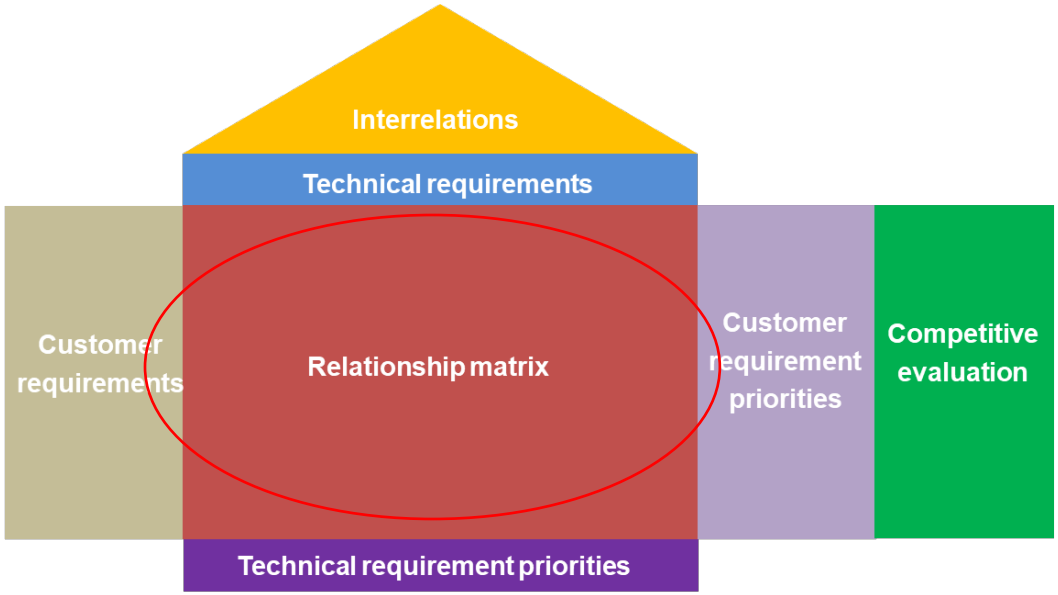
Step 2: Technical requirements (How)

Customer requirements
Long-time freshness of food
High star rating
Large internal space
Well space organisation
No frost
Long warranty period
More smart functions (e.g. displays)
Quiet
Low price

Technical requirements
Airflow type
Temperature variation
Energy consumption
Dimensions
Number of shelves and boxes
Humidity control
Service life
Smart system
Ergonomic design
Manufacturing cost

Step 3: Relationship between “what” and “how”

- How strong the technical requirements affect the customer needs:
  - Strong (5)：+
  - Moderate (3): *
  - Weak (1)： -
  - No relationship: blank



Step 3: Relationship between “what” and “how”

Strong (5)：+

Moderate (3): *

Weak (1)： -

No relationship: blank

Customer requirements	Technical requirements: Humidity control	Manufacturing cost	Service life	Number of shelves and boxes	Energy consumption (star rating)	Dimensions	Ergonomy	Temperature variation	Airflow type	Smart system
Long-time freshness of food										
High star rating										
Large internal space										
Well space organisation										
No frost										
Warranty period										
Smart functions (e.g. displays)										
Quiet										
Low price										

Step 3: Relationship between “what” and “how”

Strong (5)： +

Moderate (3): *

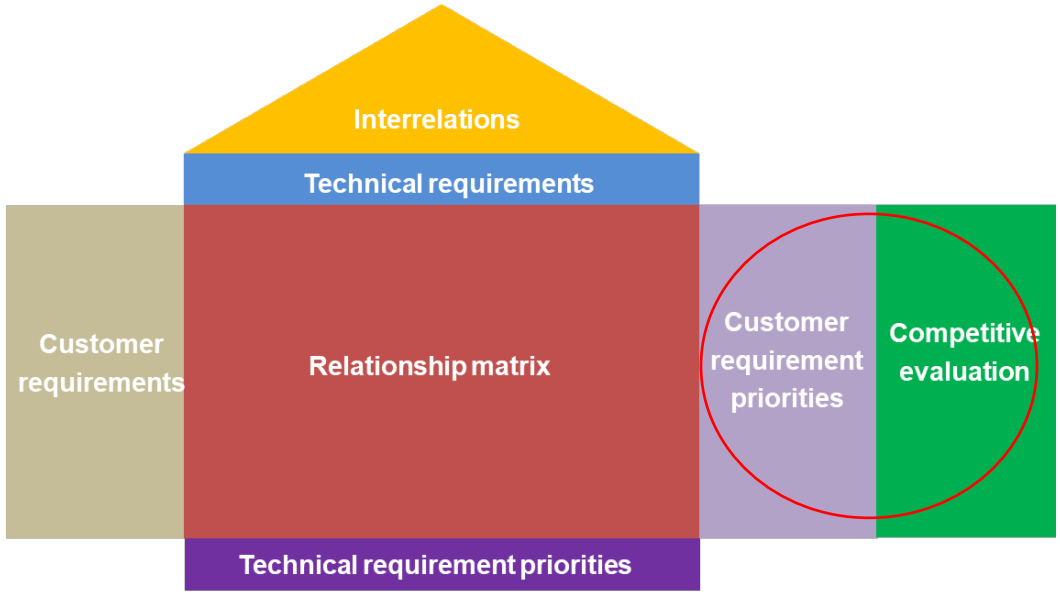
Weak (1)： -

No relationship: blank

Customer requirements \ Technical requirements	Humidity control	Manufacturing cost	Service life	Number of shelves and boxes	Energy consumption (star rating)	Dimensions	Ergonomy	Temperature variation	Airflow type	Smart system
Long-time freshness of food	+	-	*					+	+	
Low energy consumption		*			+	+		+		*
Large internal space		*			*	+				
Well space organisation		-		+						
No frost	*				*				+	
Warranty period			+							
Smart functions (e.g. displays)		+								+
Quiet		-					+			
Low price	+	+	-		+	-	-	*		+

Step 4: Competitive analysis

1. Prioritize the customer requirements
2. Define target
3. Define special emphasis
4. Calculate the weight of the customer requirements



Step 4: Competitive analysis

1. Prioritize the customer requirements
   - How important is this need for a customer?
   - How well our company meet this need?
   - How well do competitors do?

A rating approach:

5: I must have this, I expect it and I would switch brands to get it

4: It would be nice to have it, I might switch brands to get it

3: I am apathetic about it, it really does not influence my buying decision at the same of level 5 or 4

Step 4: Competitive analysis

Add importance rating (1 = low, 5 = high)

Customer requirements	Importance
Long-time freshness of food	5
High star rating	5
Large internal space	4
Well space organisation	2
No frost	4
Warranty period	3
More smart functions (e.g. displays)	1
Quiet	2
Low price	3

Step 4: Competitive analysis

1. Prioritize the customer requirements
   - How important is this need for a customer?
   - How well our company meet this need?
   - How well do competitors do?

A rating approach:

- *5: fully meets my needs, exceeds expectations in some cases*
- *3: satisfactory, not expectational or a problem or concern*
- *1: Unsatisfactory and causes aggravation. A major problem.*

Step 4: Competitive analysis

C: Competitor

		Customer Evaluation		
Customer requirements	**Importance**	**Us**	**C1**	**C2**
Long-time freshness of food	5	4	3	5
Low energy consumption	5	5	5	3
Large internal space	4	3	2	4
Well space organisation	2	4	2	3
No frost	3	4	2	5
Warranty period	3	5	3	4
More smart functions (e.g. displays)	1	3	1	4
Quiet	2	2	2	3
Low price	3	3	5	1

Step 4: Competitive analysis

C: Competitor

1. Prioritize the customer requirements
2. Define a target for each requirement
   - Scale 1-5: low to high
   - Target is the level of improvement that the company would like to have after the new product is introduced

Ratio of improvement: Target/US

Step 4: Competitive analysis

I: Importance

Ratio of improvement: Target/US

		Customer Evaluation				
Customer requirements	**I**	**Us**	**C1**	**C2**	**Target**	**Ratio**
Long-time freshness of food	5	4	3	5	5	
Low energy consumption	5	5	5	3	5	
Large internal space	4	3	2	4	4	
Well space organisation	2	2	2	3	4	
No frost	3	3	2	5	4	
Warranty period	3	5	3	4	5	
More smart functions (e.g. displays)	1	3	1	4	4	
Quiet	2	2	2	3	3	
Low price	3	3	5	1	5	

Step 4: Competitive analysis

I: Importance

Ratio of improvement: Target/US

		Customer Evaluation				
Customer requirements	**I**	**Us**	**C1**	**C2**	**Target**	**Ratio**
Long-time freshness of food	5	4	3	5	5	1.25
Low energy consumption	5	5	5	3	5	1
Large internal space	4	3	2	4	4	1.33
Well space organisation	2	2	2	3	4	2
No frost	3	3	2	5	4	1.33
Warranty period	3	5	3	4	5	1
More smart functions (e.g. displays)	1	3	1	4	4	1.33
Quiet	2	2	2	3	3	1.5
Low price	3	3	5	1	5	1.67

$\frac{4}{3}$

Step 4: Competitive analysis

1. Prioritize the customer requirements
2. Define a target for each requirement
3. Define special emphasis

   Sales point

   - *None: 1*
   - *Possible 1.2*
   - *Strong: 1.5*

Step 4: Competitive analysis

SP: Sales Point

Sales point

- *None: 1, Possible 1.2, Strong: 1.5*

Customer requirements	Importance	Us	C1	C2	Target	Ratio	SP
Long-time freshness of food	5	4	3	5	5	1.25	1.5
Low energy consumption	5	5	5	3	5	1	1.5
Large internal space	4	3	2	4	4	1.33	1.2
Well space organisation	2	2	2	3	4	2	1
No frost	3	3	2	5	4	1.33	1.2
Warranty period	3	5	3	4	5	1	1.2
More smart functions (e.g. displays)	1	3	1	4	4	1.33	1
Quiet	2	2	2	3	3	1.5	1.2
Low price	3	3	5	1	5	1.67	1.5

Step 4: Competitive analysis

SP: Sales Point

1. Prioritize the customer requirements
2. Define a target for each requirement
3. Define Special emphasis
4. Calculate the weight of the customer requirements

Weight: Ratio X Importance X Sales Point

Step 4: Competitive analysis

- Weighting the requirement

  Example calculation: 4×1.33×1.2=6.4

Customer requirements	I	Us	C1	C2	Target	Ratio	SP	Weight
Long-time freshness of food	5	4	3	5	5	1.25	1.5	
Low energy consumption	5	5	5	3	5	1	1.5	
Large internal space	4	3	2	4	4	1.33	1.2	
Well space organisation	2	2	2	3	4	2	1	
No frost	3	3	2	5	4	1.33	1.2	
Warranty period	3	5	3	4	5	1	1.2	
More smart functions (e.g. displays)	1	3	1	4	4	1.33	1	
Quiet	2	2	2	3	3	1.5	1.2	
Low price	3	3	5	1	5	1.67	1.5	

Step 4: Competitive analysis

- Weighting the requirement

  Example calculation: 4×1.33×1.2=6.4

Customer requirements	I	Us	C1	C2	Target	Ratio	SP	Weight
Long-time freshness of food	5	4	3	5	5	1.25	1.5	9.4
Low energy consumption	5	5	5	3	5	1	1.5	7.5
Large internal space	4	3	2	4	4	1.33	1.2	6.4
Well space organisation	2	2	2	3	4	2	1	4
No frost	3	3	2	5	4	1.33	1.2	4.8
Warranty period	3	5	3	4	5	1	1.2	3.6
More smart functions (e.g. displays)	1	3	1	4	4	1.33	1	1.33
Quiet	2	2	2	3	3	1.5	1.2	3.6
Low price	3	3	5	1	5	1.67	1.5	7.5

Step 5: Technical requirement priority

1. Validation of the defined relationships with test data
2. Define the importance of technical parameters
3. Comparing technical parameters with competitors
4. Defining targets for technical parameters

Technical parameter Importance=$\sum I_r S_{rt}$

I_r : importance weight of the the customer requirement
S_{rt}:the strength of the relationship between the technical parameter and I_r

Step 5

- Example:
  5×9.4+3×4.8+5×7.5=99

Customer requirements	I	Humidity control	Manufacturing cost	Service life	Number of shelves and boxes	Energy consumption (star rating)	Dimensions	Ergonomy	Temperature variation	Airflow type	Smart system	W
Long-time freshness of food	5	+	-	*					+	+		9.4
Low energy consumption	5		*			+	+		+		*	7.5
Large internal space	4		*			*	+					6.4
Well space organisation	2		-		+							4
No frost	3	*				*				+		4.8
Warranty period	3			+								3.6
Smart functions (e.g. displays)	1		+								+	1.33
Quiet	2		-					+				3.6
Low price	3	+	+	-		+	-	-	*		+	7.5
Importance of technical parameters		99										

Step 5: Technical requirement priority

1. Validation of the defined relationships with test data
2. Define the importance of technical parameters
3. Comparing technical parameters with competitors
4. Defining targets for technical parameters

Customer requirements	I	Humidity control	Manufacturing cost	Service life	Number of shelves and	Energy consumption (s	Dimensions	Ergonomy	Temperature variation	Airflow type	Smart system	Us	C1	C2	Target	Ratio	S
Long-time freshness of food	5	+	-	*					+	+		4	3	5	5	1.25	1.5
Low energy consumption	5		*			+	+		+		*	5	5	3	5	1	1.5
Large internal space	4		*			*	+					3	2	4	4	1.33	1.2
Well space organisation	2		-		+							2	2	3	4	2	1
No frost	3	*				*				+		3	2	5	4	1.33	1.2
Warranty period	3			+								5	3	4	5	1	1.2
Smart functions (e.g. displays)	1		+								+	3	1	4	4	1.33	1
Quiet	2		-					+				2	2	3	3	1.5	1.2
Low price	3	+	+	-		+	-	-	*		+	3	5	1	5	1.67	1.5
	Us	3	3	4	2	4	4	3	4	5	2						
	C1	2	5	3	2	2	2	3	3	3	1						
	C2	4	2	5	4	5	5	4	4	4	5						
Importance of technical parameters		99	116	33	8	100	85	30	107	61	61						

Comparing technical parameters with competitors

Step 5: Technical requirement priority

1. Validation of the defined relationships with test data
2. Define the importance of technical parameters
3. Comparing technical parameters with competitors
4. Defining targets for technical parameters

Customer requirements	I	Humidity control	Manufacturing cost	Service life	Number of shelves and	Energy consumption (s	Dimensions	Ergonomy	Temperature variation	Airflow type	Smart system	Us	C1	C2	Target	Ratio	S
Long-time freshness of food	5	+	-	*					+	+		4	3	5	5	1.25	1.5
Low energy consumption	5		*			+	+		+		*	5	5	3	5	1	1.5
Large internal space	4		*			*	+					3	2	4	4	1.33	1.2
Well space organisation	2		-		+							2	2	3	4	2	1
No frost	3	*				*				+		3	2	5	4	1.33	1.2
Warranty period	3			+								5	3	4	5	1	1.2
Smart functions (e.g. displays)	1		+								+	3	1	4	4	1.33	1
Quiet	2		-					+				2	2	3	3	1.5	1.2
Low price	3	+	+	-		+	-	-	*		+	3	5	1	5	1.67	1.5
Us		3	3	4	2	4	4	3	4	5	2						
C1		2	5	3	2	2	2	3	3	3	1						
C2		4	2	5	4	5	5	4	4	4	5						
		99	116	33	8	100	85	30	107	61	61						
		Yes	<$900	5 years	25	4.5 stars	85*170*80	Low noise	Yes	Brewed type	No						

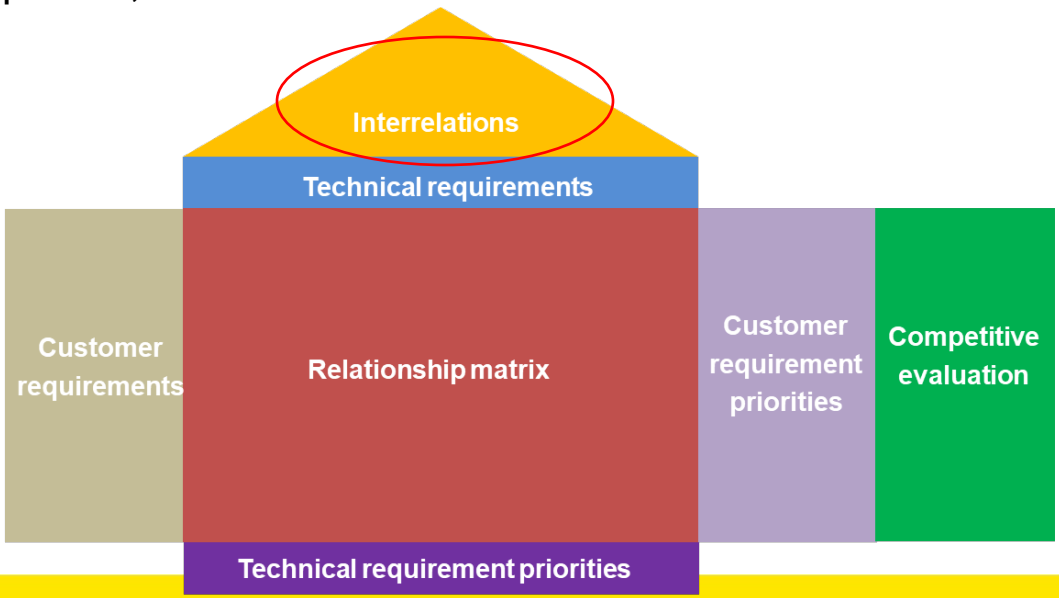
Comparing technical parameters with competitors

Importance of technical parameters

Targets for technical parameters

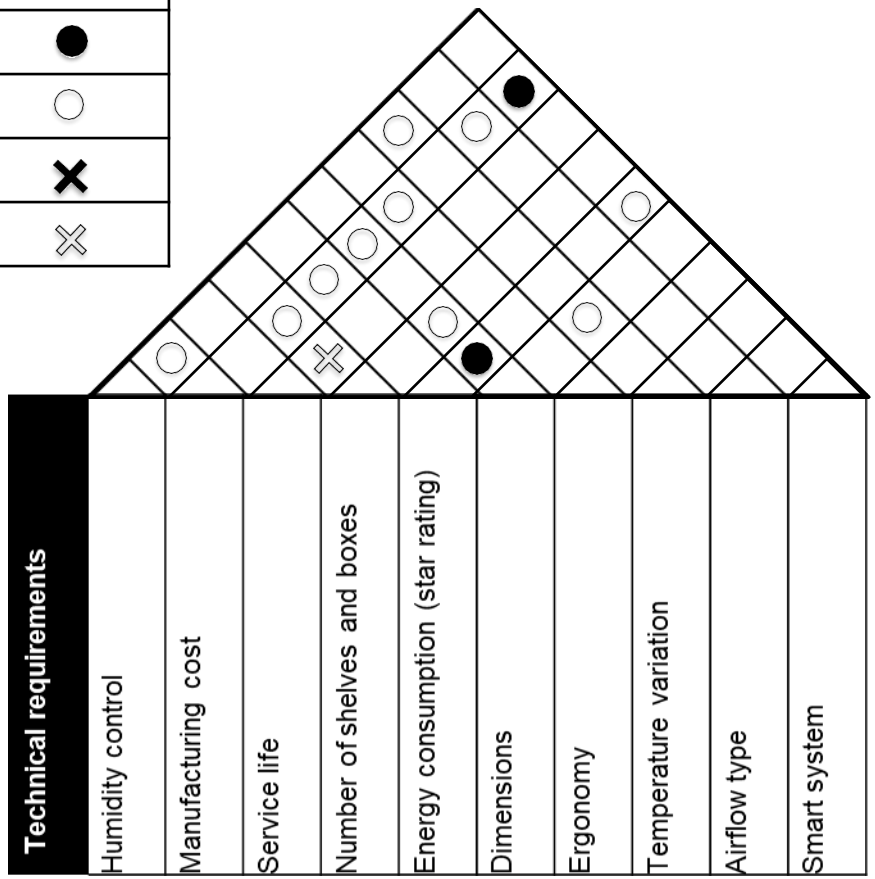
Step 6: Interrelationships between requirements

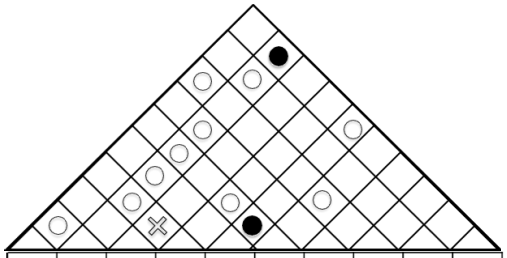
- Analysis of the technical trade-off. If one technical feature is improved
  - If there is a strong possibility that another also improve, then there is a strong positive correlation between these two technical parameters. ●
  - If there is a possibility that another also improve, then there is a positive correlation between these two technical parameters. ○
  - If there is a strong possibility that another gets worse, then there is a strong negative correlation between these two technical parameters. ✖
  - If there is a strong possibility that another gets worse, then there is a strong negative correlation between these two technical parameters. ✕
  - If it is not impacted; there is no correlation. Blank



Step 6: Interrelationships between requirements

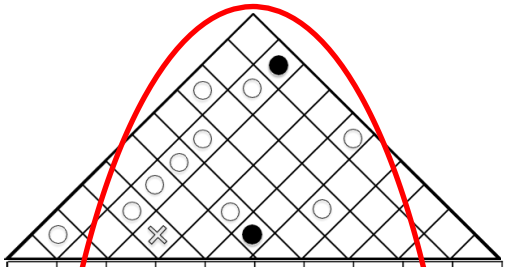
Relationship	Symbol
Strong positive	●
Week positive	○
Strong negative	✕
Week negative	✕





Customer requirements	I	Humidity control	Manufacturing cost	Service life	Number of shelves and boxes	Energy consumption (star rating)	Dimensions	Ergonomy	Temperature variation	Airflow type	Smart system	Us	C1	C2	Target	Ratio	SP	Weight
Long-time freshness of food	5	+	-	*					+	+		4	3	5	5	1.25	1.5	9.4
Low energy consumption	5		*			+	+		+		*	5	5	3	5	1	1.5	7.5
Large internal space	4		*			*	+					3	2	4	4	1.33	1.2	6.4
Well space organisation	2		-		+							2	2	3	4	2	1	4
No frost	3	*				*				+		3	2	5	4	1.33	1.2	4.8
Warranty period	3			+								5	3	4	5	1	1.2	3.6
Smart functions (e.g. displays)	1		+								+	3	1	4	4	1.33	1	1.33
Quiet	2		-					+				2	2	3	3	1.5	1.2	3.6
Low price	3	+	+	-		+	-	-	*		+	3	5	1	5	1.67	1.5	7.5
Us		3	3	4	2	4	4	3	4	5	2							
C1		2	5	3	2	2	2	3	3	3	1							
C2		4	2	5	4	5	5	4	4	4	5							
		84	116	33	8	100	85	30	107	61	61							
		Yes	<$900	5 years	25	4.5 stars	85*170*80	Low noise	Yes	Brewed type	No							

Different parts of the House



Customer requirements	I	Humidity control	Manufacturing cost	Service life	Number of shelves and boxes	Energy consumption (star rating)	Dimensions	Ergonomy	Temperature variation	Airflow type	Smart system	Us	C1	C2	Target	Ratio	SP	Weight
Long-time freshness of food	5	+	-	*					+	+		4	3	5	5	1.25	1.5	9.4
Low energy consumption	5		*			+	+		+		*	5	5	3	5	1	1.5	7.5
Large internal space	4		*			*	+					3	2	4	4	1.33	1.2	6.4
Well space organisation	2		-		+							2	2	3	4	2	1	4
No frost	3	*				*				+		3	2	5	4	1.33	1.2	4.8
Warranty period	3			+								5	3	4	5	1	1.2	3.6
Smart functions (e.g. displays)	1		+								+	3	1	4	4	1.33	1	1.33
Quiet	2		-					+				2	2	3	3	1.5	1.2	3.6
Low price	3	+	+	-		+	-	-	*		+	3	5	1	5	1.67	1.5	7.5
Us		3	3	4	2	4	4	3	4	3	2							
C1		2	5	3	2	2	2	3	3	3	1							
C2		4	2	5	4	5	5	4	4	4	5							
		84	116	93	8	100	85	30	107	61	61							
		Yes	<$900	5 years	25	4.5 stars	85*170*80	Low noise	Yes	Brewed type	No							

Customer Information Section

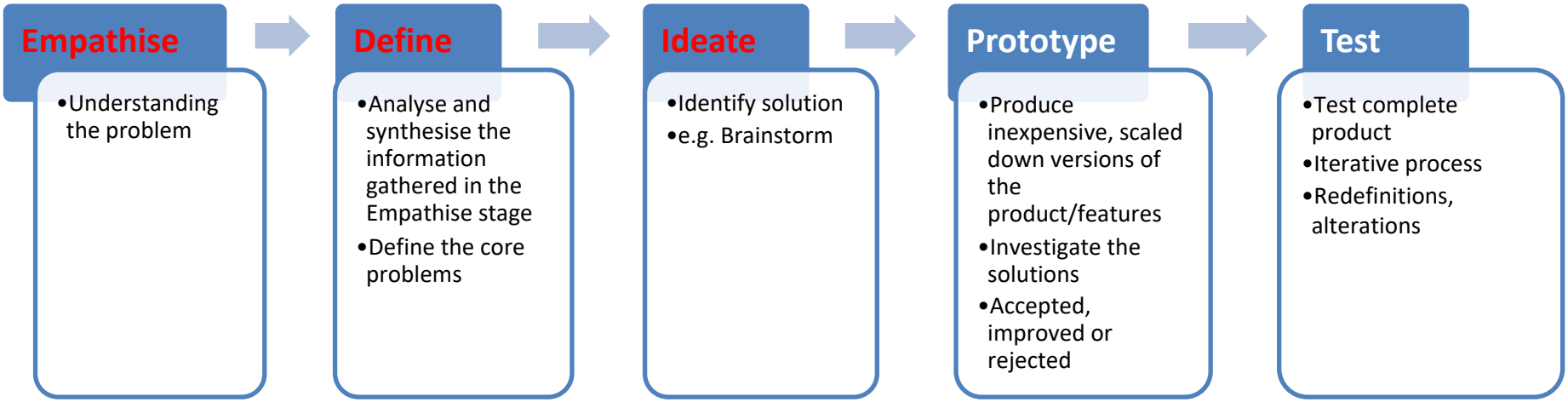
Technical Information Section

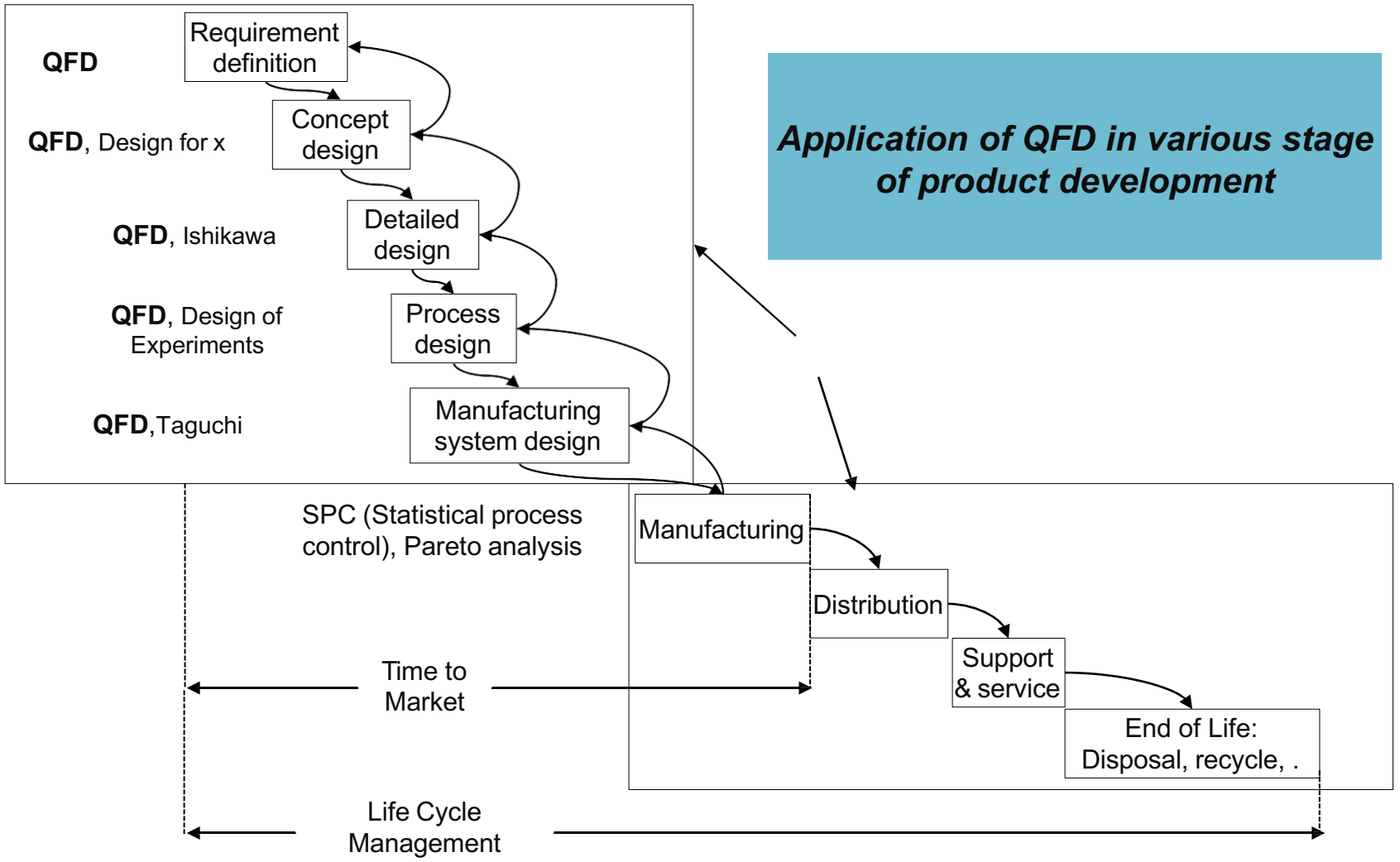
Check the matrix

1. Blank rows and blank columns
2. Technical requirements with large # of relationships with negative correlation
3. Find the interaction between important customer requirements, important technical parameters, and their correlation
   - E.g. One technical requirement may improve one customer requirement but worsen another important customer requirement

QFD as a tool

- QFD matrix is a tool, not the end. It is a good communication tool at each step in the process of product development.
- During the process, a team of people representing various functional departments are involved in developing the products: Design Engineering, Marketing, Manufacturing Engineering, Finance, Product Support etc.
- The real value is the communicating and decision making process in the QFD.
- During the communication among different departments, the “hidden knowledge” that is not known by one department but known by others will be found and considered at each stage.

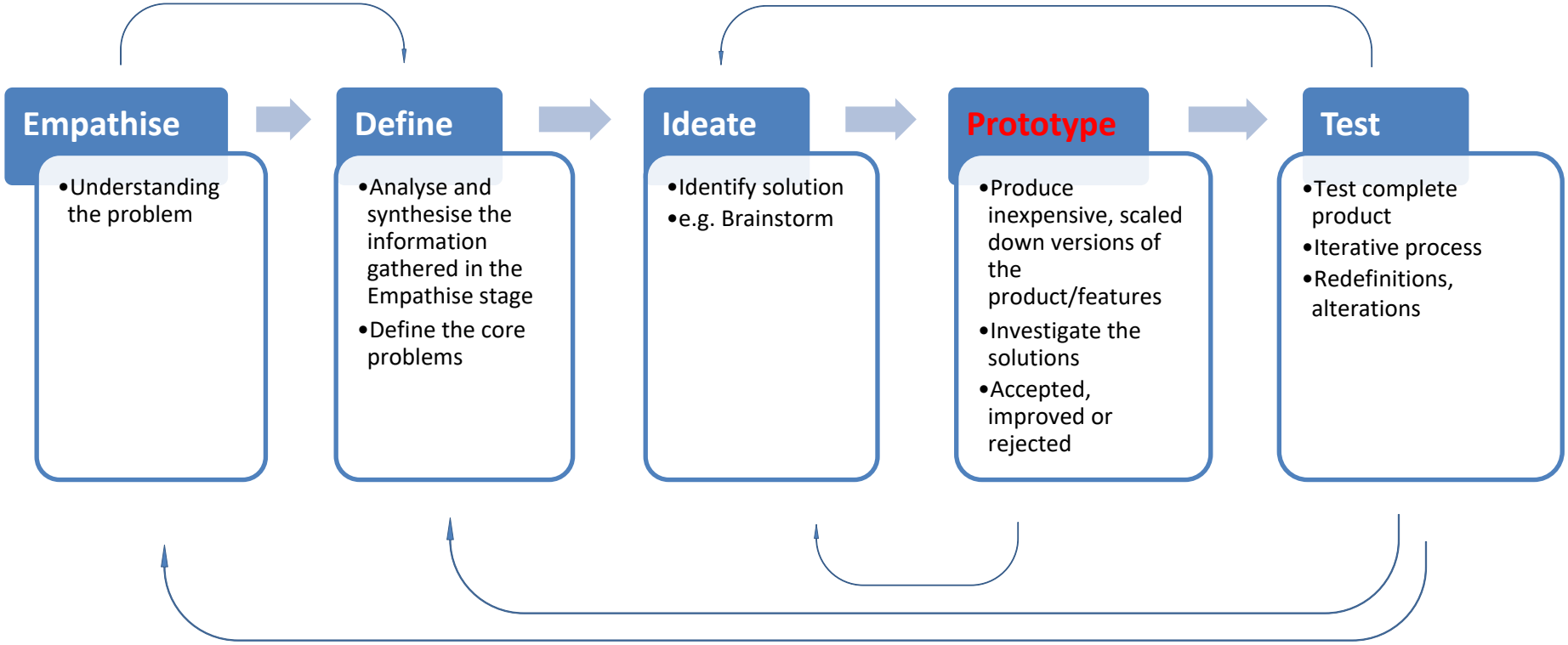




Application of QFD in various stage of product development

Prototype

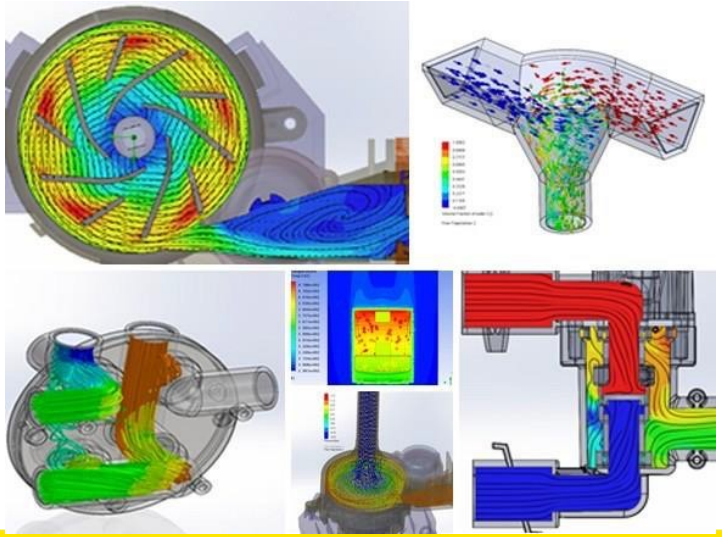
- When designers want to test their solutions/features/functions in a different way (tangible rather than abstract)
- The early versions of their products is known as prototypes
- Invest less time and money spent on an idea that turns out to be a bad one.



Types of Prototype

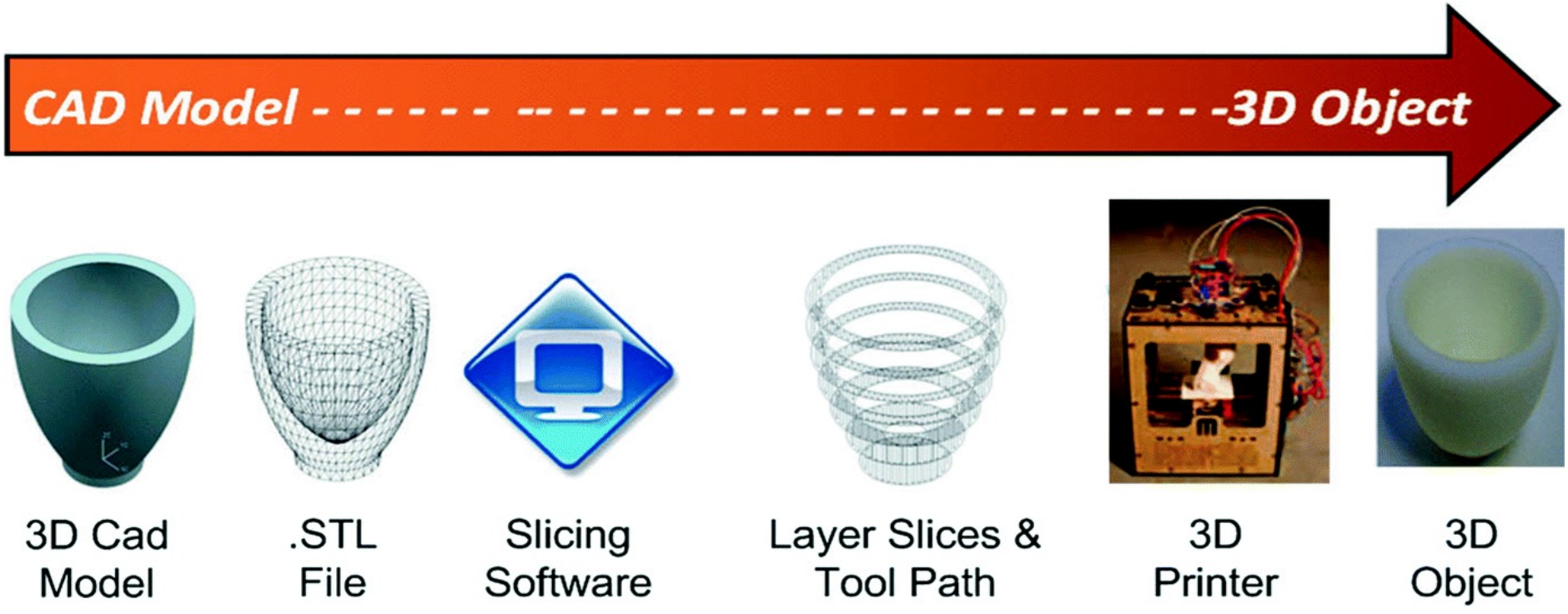
- The nature of the prototype:
  - **Physical Prototype**:
    - A tangible object that can be seen and handle
    - Can be used for experiments to test the function, or/and visual appearance

  - **Analytical Prototype**:
    - A non-tangible representation of the product,
    - A simulation model, a 3D video image or CAD model, or a mathematical model for engineering analysis



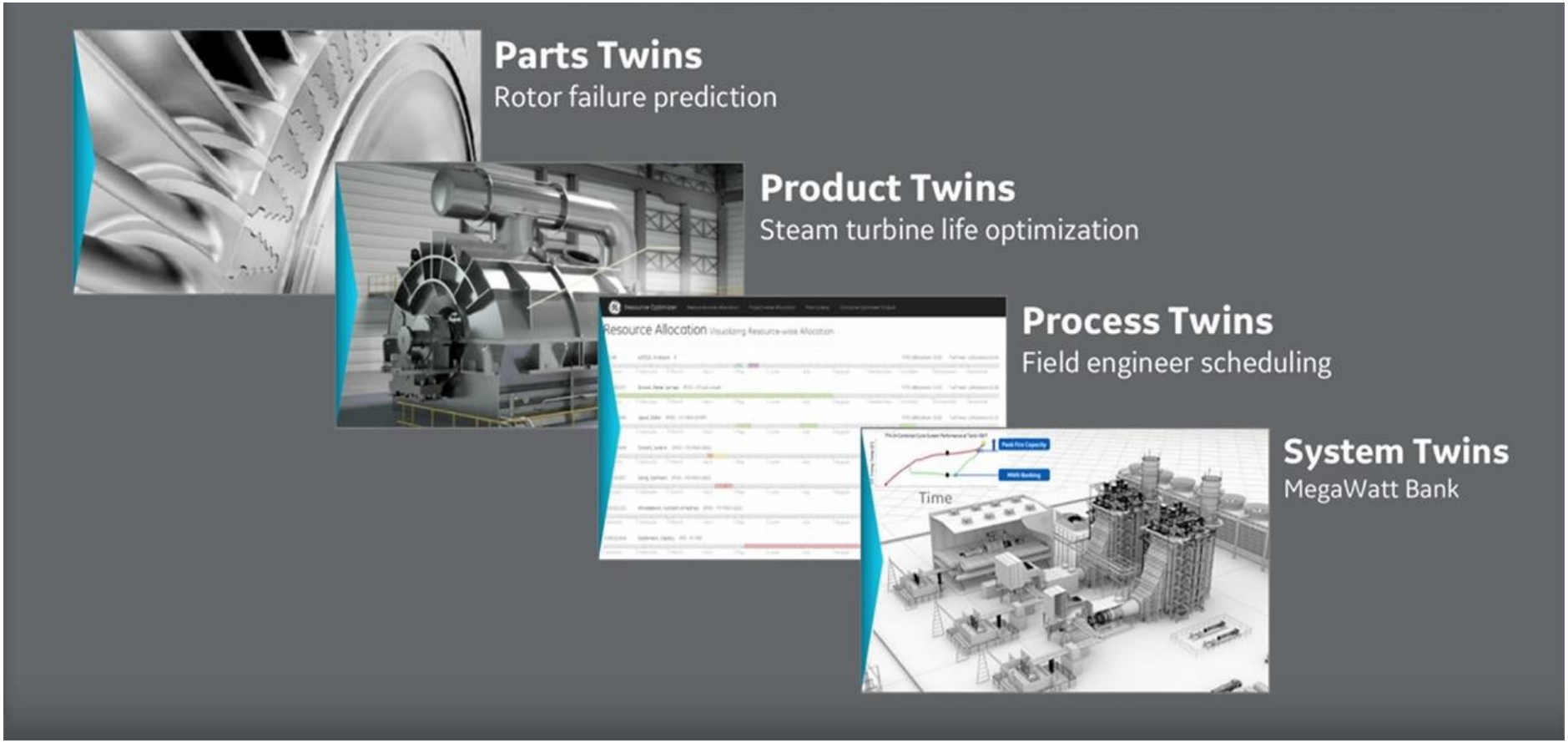
Example: 3D printing technology

When developing devices, designers can use 3D printing technology to provide stakeholders with accurate and testable/useable replica models with a more instant and low cost process.



Example: Digital twin

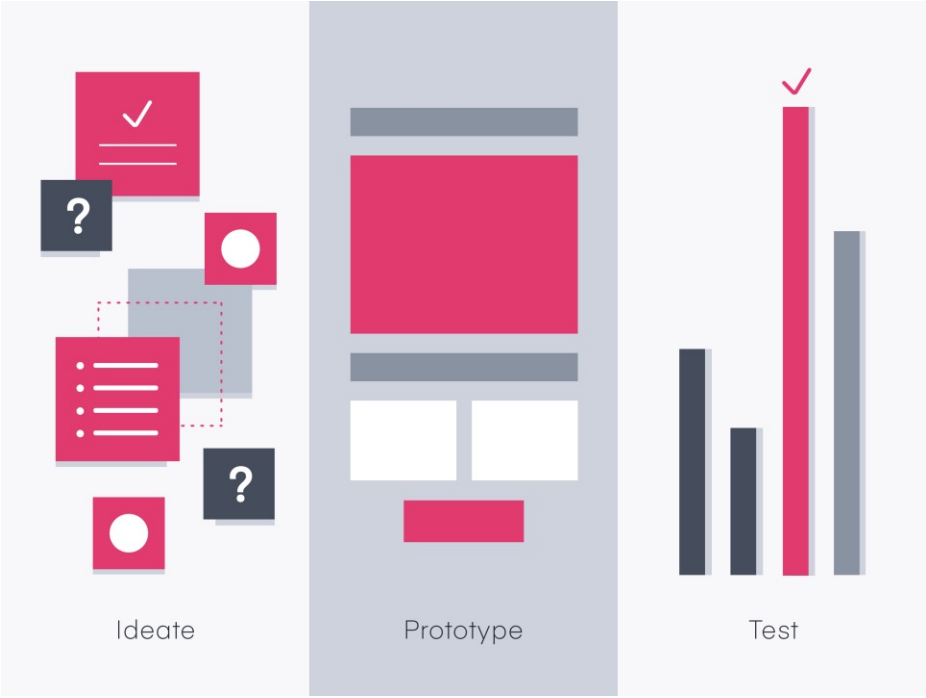
- Digital replica of a physical object/process
- Early design models can be employed later in the production to stand as or be part of a bigger digital twin



Purposes of Prototype

1) Learning Tool

- To analyse:
  - Functionality :“will it work?”,
  - Capability/Feasibility: “can we make it?”
  - Desirability: “what does the customer think?”



2) Communication Tool

- Engage with end users/stakeholders, managers, team members.
- Reveal deeper insights and discussion to inform design decisions going forward

Purposes of Prototype

3) Integration Tool

- To test the interaction of components or subassemblies in terms of function and fit

4) Time Management tool

- Define milestones: Prototypes are used to demonstrate the stages of development or the level of functionality (usually defined as project milestones) to top management.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