INSE 6411
Product Design Theory and Methodology

Customer needs and product specifications
Lectures 5-6

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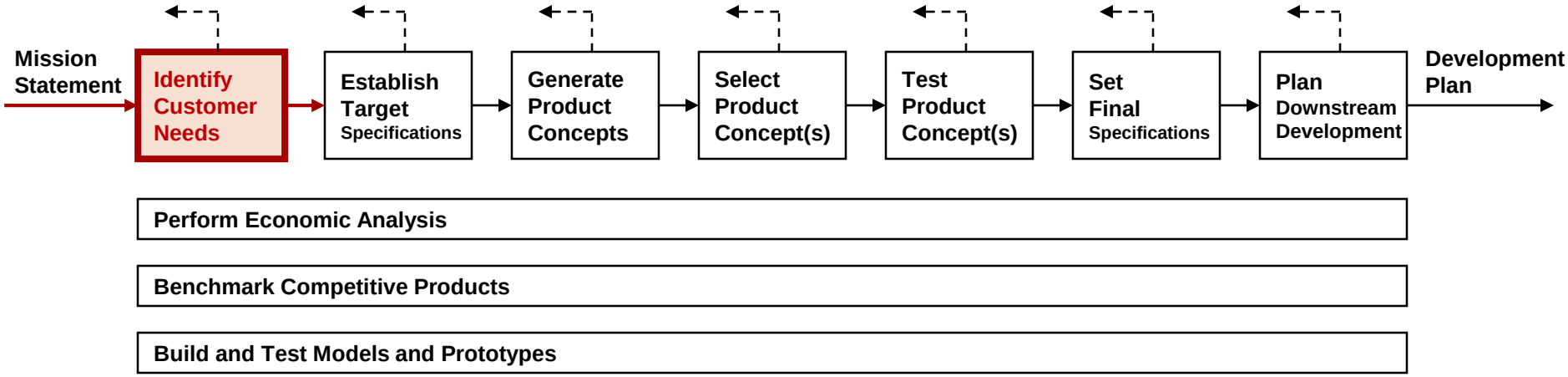
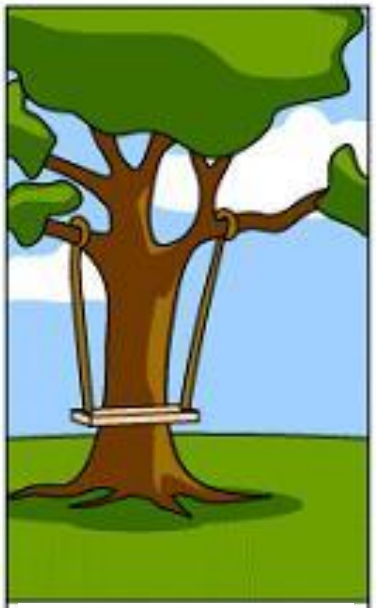
Product Development Process

Concept Development Process



How the customer described it

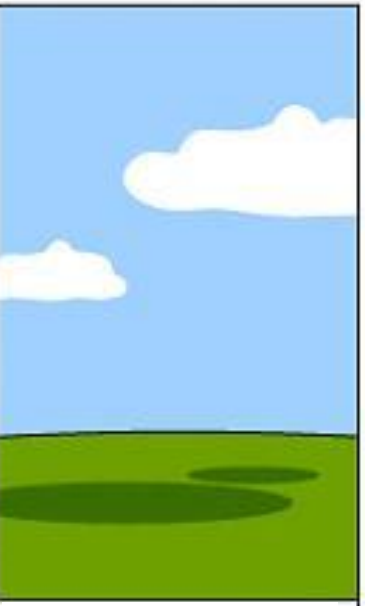


How the marketing specialist understood it

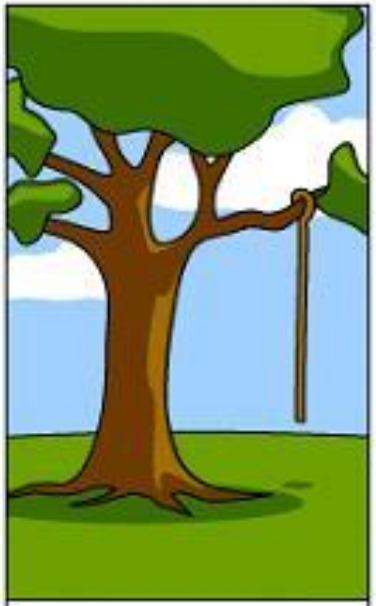
How the designer designed it

How the programmer wrote it

How it was advertised

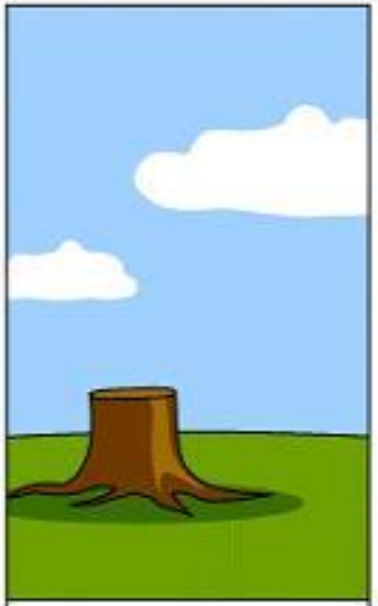


How it was documented



What was in the manufacturing plan

How was the customer billed



The final piece

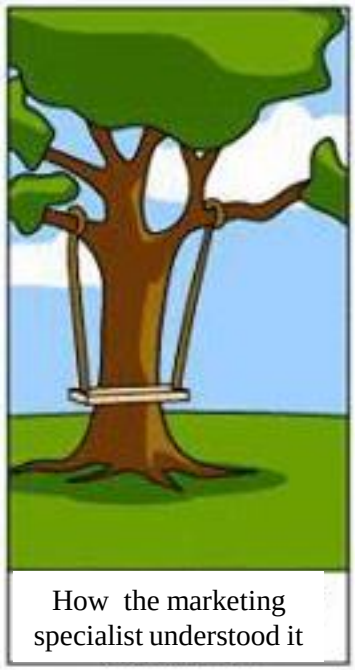
What the customer really wanted

How the customer described it

Observation 1:

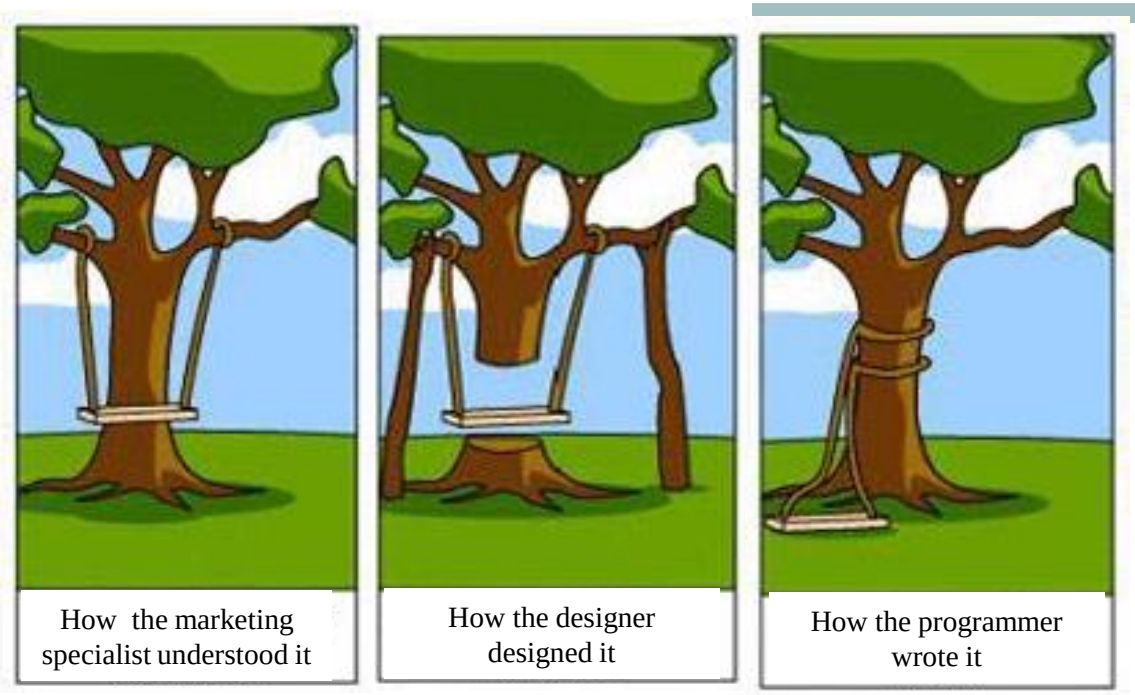
The customers may not know exactly what they want !

What the customer really wanted



Observation 2:

Customer's needs may be misinterpreted in the process of communication!



Observation 3:

Implicit requirements may be ignored in the process of product development!

Identifying Customer Needs

Textbook - Chapter 5

Identifying customer needs

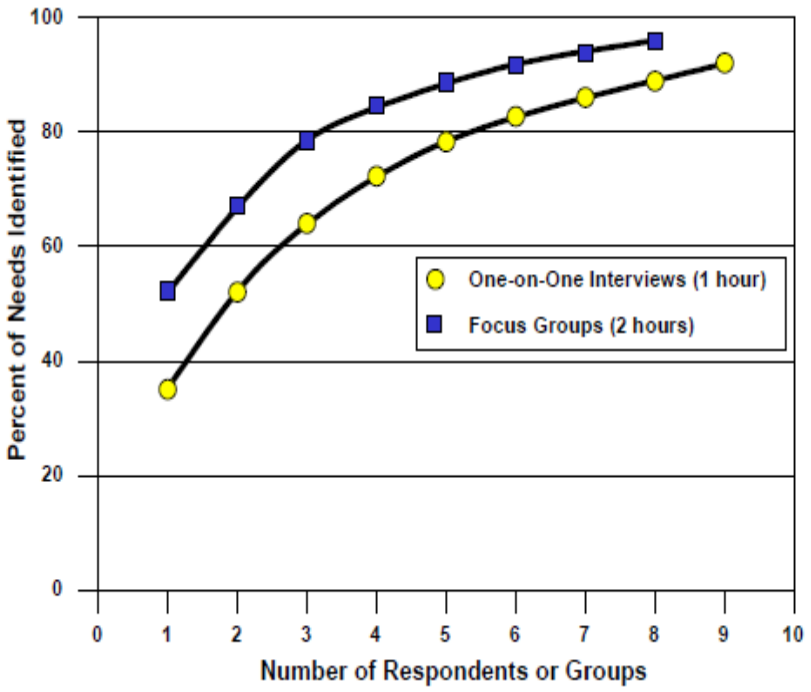
- ***Needs*** are independent of any particular concept
  - The list of customer needs can be developed without knowing how these needs will be addressed
  - Also called “customer attributes” or “customer requirements”
- ***Specifications*** depend on the selected concept
  - They depend on:
    - Customer needs
    - What is feasible
    - What competitors offer

Identification of customer needs:

1. Gather raw data from customers
2. Interpret raw data in terms of customer needs
3. Organize the needs into hierarchy

1. Gathering Raw Customer Data

- **Interviews**:
  - One or more development team members discuss needs with a single customer.
    - usually in customer's environment
    - typical duration: (1-2 hours)
- **Focus groups**:
  - A moderator facilitates discussions (2 hours) with a group of customers (8 to 12)
- **Written surveys:**
  - Do not usually provide enough information at this stage
- **Observing the product in use**:
  - Watching customers use an existing product can reveal important details or hidden customer needs



1. Gathering Raw Customer Data
Visual information – Example: Backpack

The backpack is carried over one shoulder only

The backpack is carried by the handle only

The backpack may need to be accessed with one hand only

The backpack may contain a lot of diverse items

1. Gathering Raw Customer Data

Whom to ask?

- Both **end users** and **buyers**
- **Lead users**
  - Customers who experience needs months or years ahead of the majority of the marketplace
- **Non-traditional customers**
  - Happy, dissatisfied, demanding, customers you had but lost, customers you never had
- **Extreme users**
  - Customers who use the product in unusual ways or have special needs

"Good Grip" vegetable peeler developed by Sam Farber whose wife had arthritis

1. Gathering Raw Customer Data

- **Eliciting Customer Needs**
  - The goal: an honest expression of the needs of the customer
  - Interview the end user (and the buyer)
  - Questions:
    - When and why do you use the product?
    - 'Walk us through' a typical session using the product
    - What do you like about the existing products?
    - What do you dislike about the existing products?
    - What issues do you consider when purchasing the product?
    - What improvements would you make to the product?
- **Documenting Customer Interactions**
  - Notes
  - Audiotape recording
  - Videotape recording
  - Still photography (you may include it in your project report)

➔The final result of the phase is a set of ***customer statements***

2. Interpret Raw Customer Data

- Translate *customer statements* into *customer needs*
- ***Customer needs*** are written statements interpreting the need based on the collected raw data

2. Interpret Raw Customer Data

Example – a backpack

Customer statement	*Translated customer needs statement*
"See how the leather on the bottom of the bag is all scratched; it's ugly."	The bag maintains its original appearance with use.
"When I'm standing in line at the cashier trying to find my checkbook while balancing my bag on my knee, I feel like a stork."	Items stored in the bag can be easily found and accessed.
"This bag is my life; if I lose it I'm in big trouble."	The bag is difficult to lose. The bag is easy to find if misplaced.
"There's nothing worse than a banana that's been squished by the edge of a textbook."	The bag protects delicate, soft items from damage.
"I never use both straps on my knapsack; I just sling it over one shoulder."	The bag can rest securely in multiple modes (one or both shoulders).

2. Interpret Raw Customer Data

Example – a screwdriver (SD)

Question/Prompt	Customer Statement	Interpreted Need
Typical uses	I need to drive screws fast, faster than by hand.	The SD drives screws faster than by hand.
	I sometimes do duct work; use sheet metal screws.	The SD drives sheet metal screws into metal duct work.
	A lot of electrical; switch covers, outlets, fans, kitchen appliances.	The SD can be used for screws on electrical devices.
Likes—current tool	I like the pistol grip; it feels the best.	The SD is comfortable to grip.
	I like the magnetized tip.	The SD tip retains the screw before it is driven.
Dislikes—current tool	I don't like it when the tip slips off the screw.	The SD tip remains aligned with the screw head without slipping.
	I would like to be able to lock it so I can use it with a dead battery.	The user can apply torque manually to the SD to drive a screw. (!)
	Can't drive screws into hard wood.	The SD can drive screws into hard wood.
	Sometimes I strip tough screws.	The SD does not strip screw heads.
Suggested improvements	An attachment to allow me to reach down skinny holes.	The SD can access screws at the end of deep, narrow holes.
	A point so I can scrape paint off of screws.	The SD allows the user to work with screws that have been painted over.
	Would be nice if it could punch a pilot hole.	The SD can be used to create a pilot hole. (!)

2. Interpret Raw Customer Data

- Several team members should interpret the needs
- Tips for interpreting raw customer data in terms of 'customer needs':
  1. Express the need in terms of **what** the product must do, **not how** it might do it.
  2. Express the need as specifically as in the raw data
  3. Use positive not negative phrasing
  4. Express the need as an attribute of the product
  5. Avoid the words 'must' and 'should'

2. Interpret Raw Customer Data

Example – a screwdriver

Guideline	Customer Statement	Need Statement-Wrong	Need Statement-Right
What not How	"Why don't you put protective shields around the battery contacts?"	The screwdriver battery contacts are covered by a plastic sliding door.	The screwdriver battery is protected from accidental shorting.
Specificity	"I drop my screwdriver all the time."	The screwdriver is rugged.	The screwdriver operates normally after repeated dropping.
Positive not Negative	"It doesn't matter if it's raining, I still need to work outside on Saturdays."	The screwdriver is not disabled by the rain.	The screwdriver operates normally in the rain.
Attribute of the Product	"I'd like to charge my battery from my cigarette lighter."	An automobile cigarette lighter adapter can charge the screwdriver battery.	The screwdriver battery can be charged from an automobile cigarette lighter.
Avoid "Must" and "Should"	"I hate it when I don't know how much juice is left in the batteries of my cordless tools."	The screwdriver should provide an indication of the energy level of the battery.	The screwdriver provides an indication of the energy level of the battery.

3. Organize the needs into a hierarchy

- Around 50-300 customer needs
  - We need some organization!
- Create a hierarchy in the needs:
  - Primary needs
  - Secondary needs
  - (Tertiary needs)
- The procedure:
  - Organize the needs into the groups according to the similarity of the needs (secondary needs)
  - Eliminate redundant statements
  - For each group chose a label (primary need)

2. Organize the needs into hierarchy

Example - screwdriver

The SD provides plenty of power to drive screws.
The SD maintains power for several hours of heavy use.
The SD can drive screws into hardwood.
The SD drives sheet metal screws into metal ductwork.
The SD drives screws faster than by hand.

The SD makes it easy to start a screw.
The SD retains the screw before it is driven.
The SD can be used to create a pilot hole.

The SD works with a variety of screws.
The SD can turn philips, torx, socket, and hex head screws.
The SD can turn many sizes of screws.

The SD can access most screws.
The SD can be maneuvered in tight areas.
The SD can access screws at the end of deep, narrow holes.

The SD turns screws that are in poor condition.
The SD can be used to remove grease and dirt from screws.
The SD allows the user to work with painted screws.

The SD feels good in the user's hand.
The SD is comfortable when the user pushes on it.
The SD is comfortable when the user resists twisting.
The SD is balanced in the user's hand.
The SD is equally easy to use in right or left hands.
The SD weight is just right.
The SD is warm to touch in cold weather.
The SD remains comfortable when left in the sun.

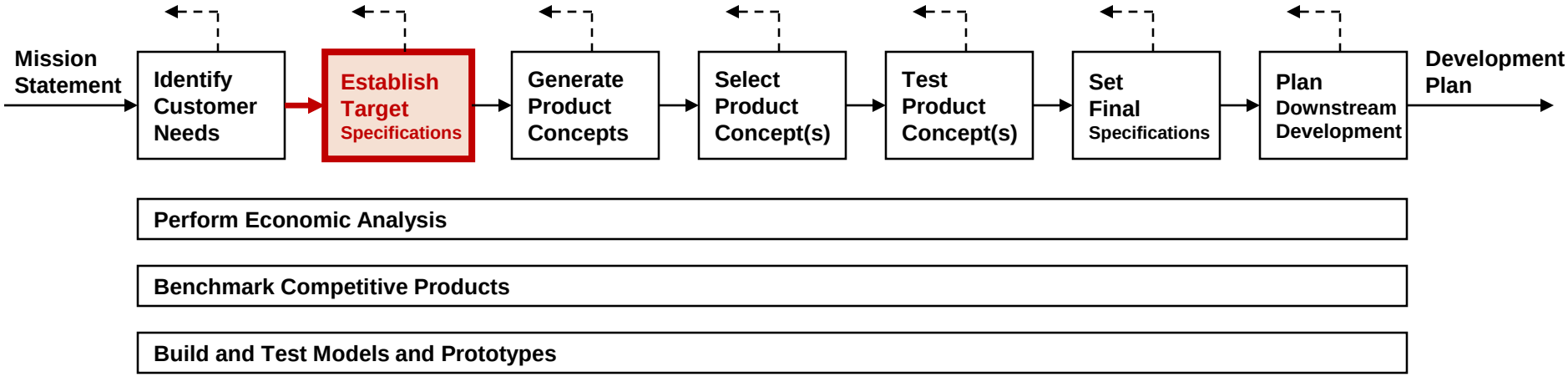
The SD is easy to control while turning screws.
The user can easily push on the SD.
The user can easily resist the SD twisting.
The SD can be locked "on."
The SD speed can be controlled by the user while turning a screw
The SD remains aligned with the screw head without slipping.
The user can easily see where the screw is.
The SD does not strip screw heads.
The SD is easily reversible.

Engineering Specifications

QFD example based on *The Mechanical Design Process* by D. Ullman (Chapter 6)

Textbook – Chapter 6

Concept Development Process

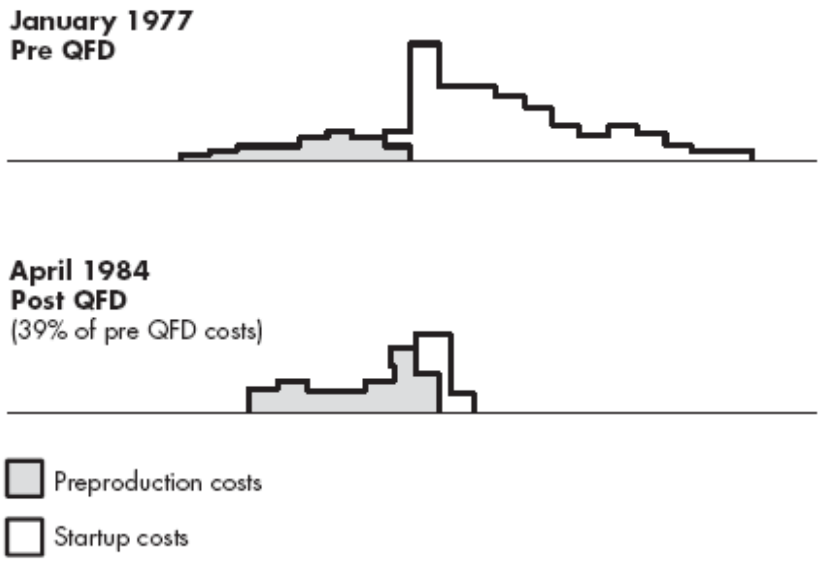


Development of engineering specifications

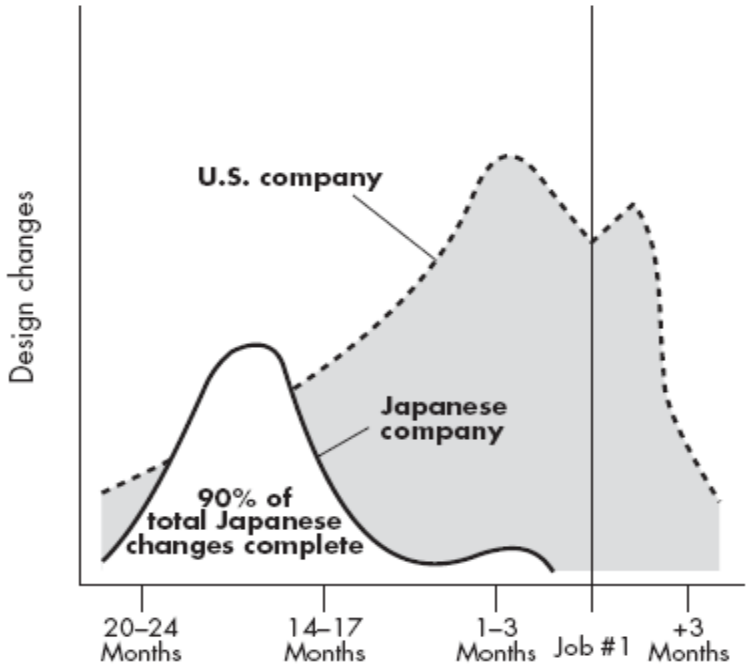
- Translate customer needs into technical description of what needs to be designed
- **Poor product definition is a factor of 80% of all time-to-market delays**
- 35% of delays is caused by "**creeping specifications**", *i.e.* specifications which get changed during the design process
  - better knowledge allows adding features
  - new technologies incorporation
  - reactions to new competitive products
  - redesign caused by changes of other specifications
- Changes should be done in a controlled and informed manner – structured methods
- Many methods to generate engineering specifications
  - **Quality Function Deployment (QFD)**
    - Japan mid-1970s
    - USA late 1980s

Quality Function Deployment (QFD)

Startup and preproduction costs at Toyota Auto Body before and after QFD



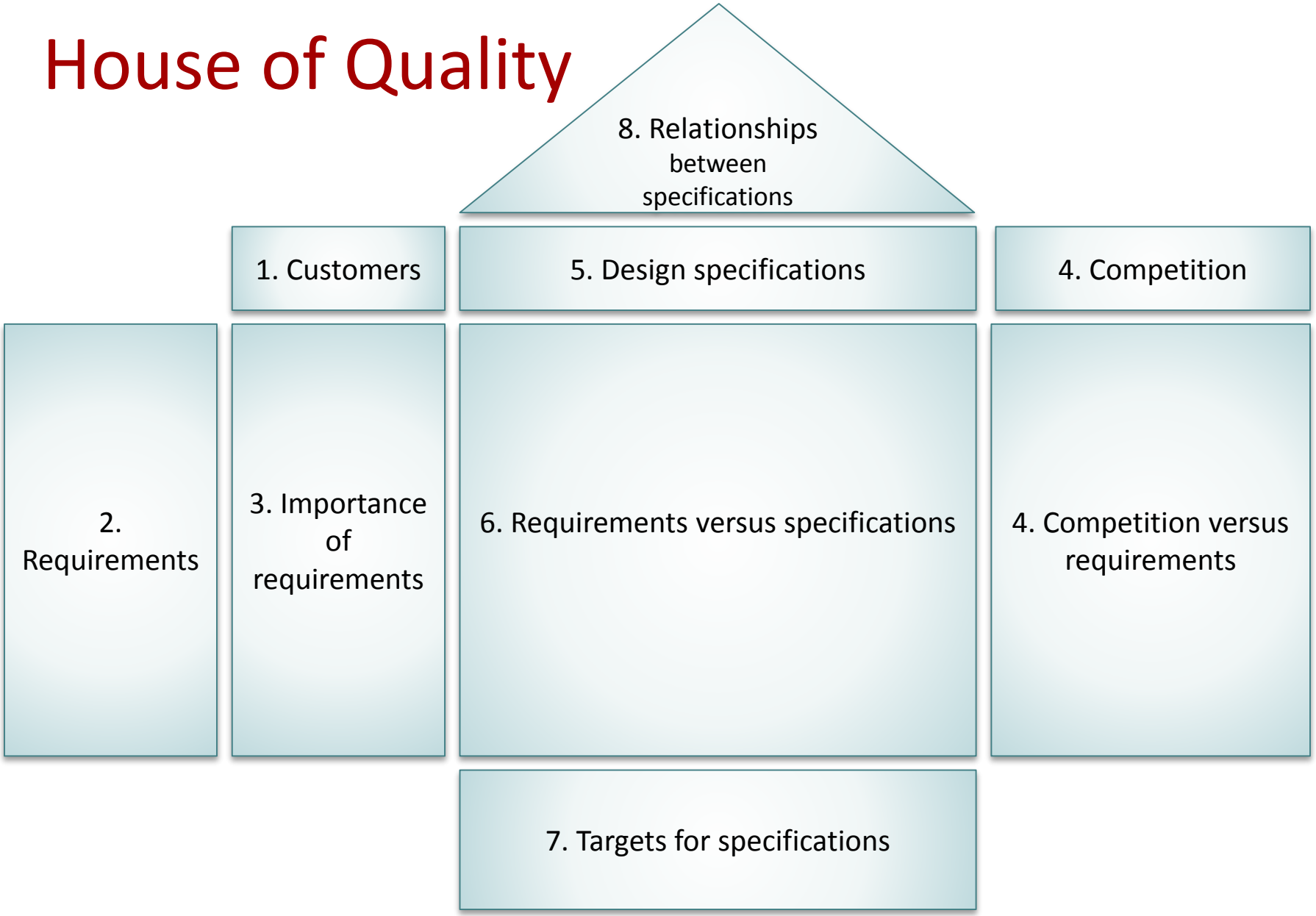
Japanese automaker with QFD made fewer changes than U.S. company without QFD



- TOYOTA:
  - Reduced the cost by over 60%
  - Decreased time-to-market by 1/3
  - QFD helps reduce changes:
    - Structured method
    - Early definition of specifications
    - Early project understanding

- USA today:
  - 69% of US companies nowadays use QFD

House of Quality



Typical aisle chair

⊙ = 9
○ = 3
Δ = 1

What			Who: Passenger	Who: Agent	How: Seat width relative to frame width ↑ %	How: Steps to adjust seat height ↑ steps	How: Force to adjust seat height ↓ N	How: Force to slide 95% male passenger ↓ N	How: Lifting force required for agent ↓ N	How: Push force over 2 cm bump ↓ N	How: Force to push aisle chair ↓ N	How: Time to transfer between seats ↓ sec	How: Fore/aft tipping force at handles ↑ N	How: Side tipping force at handles ↑ N
Transfer from personal to aisle chair	Aisle chair preparation	Easy positioning of seat height	4	4		⊙	⊙							
		Easy to position chairs	6	10	⊙									
	Passenger movement	Minimum effort for all	15	10				⊙	⊙					
		Good lifting position	10	12	○									
		Minimum time for transfer	3	14		Δ						⊙		
Aisle chair movement		Easy to move	7	8						⊙	⊙		○	○
		Fits in aircraft aisle	-	-										
		Good stability	24	10									⊙	⊙
Transfer from aisle chair to seat	Aisle chair preparation	Aisle chair close to aircraft seat	6	2	⊙									
		Easy positioning of seat height	5	8		⊙	⊙							
	Passenger movement	Minimum effort for all	15	12		○	○				⊙			
		Minimum transfer time	5	10		Δ						⊙		
Importance (Passenger)			10	9	8	9	9	4	14	5	16	16		
(Agent)			11	13	11	7	7	5	14	16	8	8		
Colub			85	2	3	20	15	11	7	15	20	15		
Deltor			87	3	5	27	25	22	15	18	15	10		
Target (Delighted)			90	1	2	20	10	8	7	15	15	10		
Threshold (Disgusted)			85	2	4	25	15	12	10	18	20	12		

Now: 1 = very bad, 5 = very good

▸ Colub
■ Deltor

1	2	3	4	5
	▸	■		
		▸ ■		
	■	▸		
			▸	■
	▸ ■			
	■			▸
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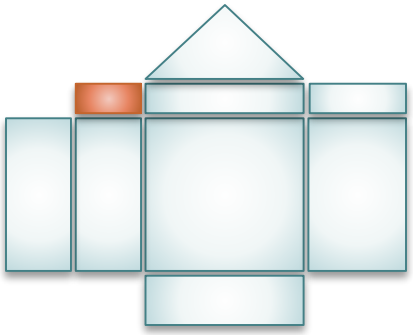
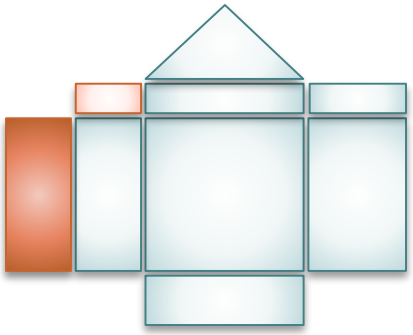


1. Customers

- Who are the customers?
- Usually more than one kind of customers
  - More kinds of users (passenger, agent)
  - Purchaser is not the same as user (gym equipment, toys)
  - Other important entities can be considered as customers – *e.g.* standards organizations

⊙ = 9
○ = 3
Δ = 1

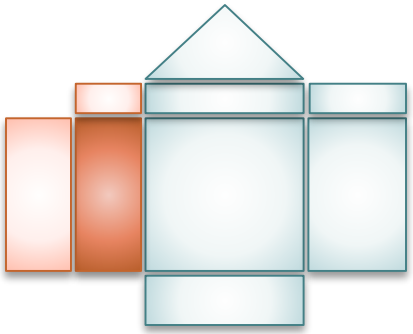
What			Who		How									
			Passenger	Agent	Seat width relative to frame width	Steps to adjust seat height	Force to adjust seat height	Force to slide 95% male passenger	Lifting force required for agent	Push force over 2 cm bump	Force to push aisle chair	Time to transfer between seats	Fore/aft tipping force at handles	
			→	→	↓	↓	↓	↓	↓	↓	↓	↓	↑	
			%	steps	N	N	N	N	N	N	N	sec	N	
Transfer from personal to aisle chair	Aisle chair preparation	Easy positioning of seat height	4	4		⊙	⊙							
		Easy to position chairs	6	10	⊙									
	Passenger transfer	Minimum effort for all	15	10				⊙	⊙					
		Good												



2. Customer requirements

- Customer requirements (customer needs) organized in a hierarchical structure

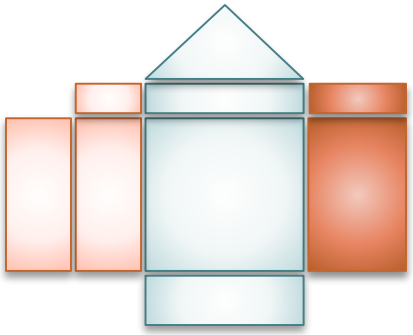
What			Passeng	Agent	↑	↑	↓	↓	↓	↓	↓	↓	↑	↑	1	2
					%	steps	N	N	N	N	N	sec	N	N		
Transfer from personal to aisle chair	Aisle chair preparation	Easy positioning of seat height	4	4		⊙	⊙									▶
		Easy to position chairs	6	10	⊙											
	Passenger movement	Minimum effort for all	15	10				⊙	⊙							■
		Good lifting position	10	12	○											
		Minimum time for transfer	3	14		Δ						⊙				▶ ■
Aisle chair movement		Easy to move	7	8						⊙	⊙		○	○		■
		Fits in aircraft aisle	-	-												
		Good stability	24	10									⊙	⊙	▶	■
Transfer from aisle chair to seat	Aisle chair preparation	Aisle chair close to aircraft seat	6	2	⊙											▶
		Easy positioning of seat height	5	8		⊙	⊙									
	Passenger movement	Minimum effort for all	15	12		○	○				⊙					▶
		Minimum transfer time	5	10		Δ						⊙				▶
Importance (Passenger)					10	9	8	9	9	4	14	5	16	16		



3. Importance of requirements

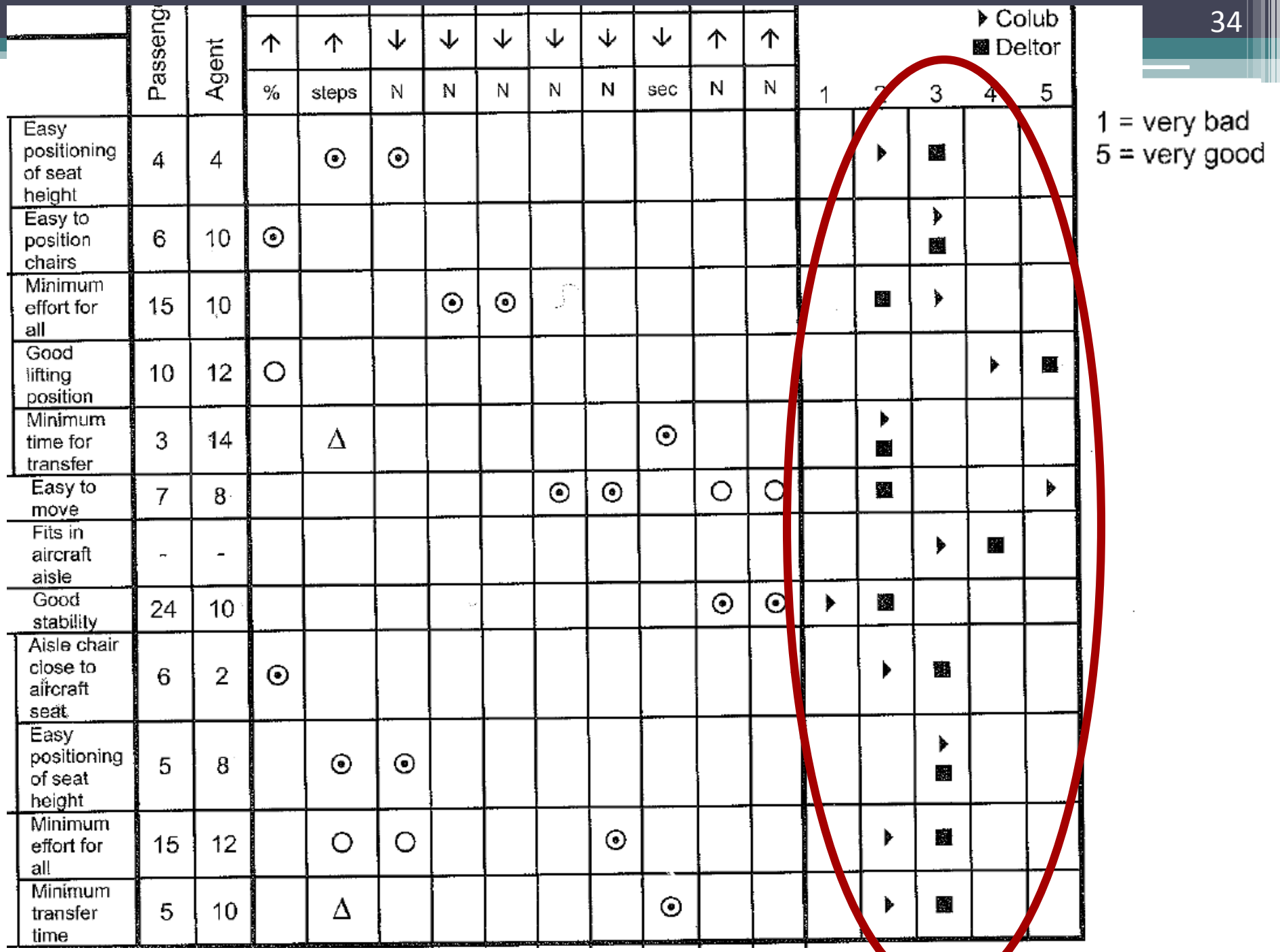
- Evaluating the importance of each of the customer requirements
- Weighting factor for each requirement & customer
  - ***Scale 1 to 10*** – often used
    - May not be very successful – too many 8s, 9s and 10s!
  - ***Fixed sum method*** **-** distribution of 100 points among all the requirements
    - Arrange the needs in order of importance
    - Allocate 100 points among them
  - Basic requirements are not rated
    - ***Basic requirement*** is a necessary feature in a product, without which the product is useless

What			Passenger	Agent	Seat w	Steps	Force	Force passe	Lifting	Push f	Force	Time t	Fore/a	Side t	1	2	3
			↑	↑	↓	↓	↓	↓	↓	↓	↓	↑	↑				
			%	steps	N	N	N	N	N	sec	N	N					
Transfer from personal to aisle chair	Aisle chair preparation	Easy positioning of seat height	4	4		⊙	⊙									▸	■
		Easy to position chairs	6	10	⊙												▸ ■
	Passenger movement	Minimum effort for all	15	10				⊙	⊙							■	▸
		Good lifting position	10	12	○												
		Minimum time for transfer	3	14		Δ						⊙				▸ ■	
Aisle chair movement		Easy to move	7	8						⊙	⊙		○	○		■	
		Fits in aircraft aisle	-	-													▸
		Good stability	24	10									⊙	⊙	▸	■	
Transfer from aisle chair to seat	Aisle chair preparation	Aisle chair close to aircraft seat	6	2	⊙											▸	■
		Easy positioning of seat height	5	8		⊙	⊙										▸ ■
	Passenger movement	Minimum effort for all	15	12		○	○				⊙					▸	■
		Minimum transfer	5	10		Δ						⊙				▸	■

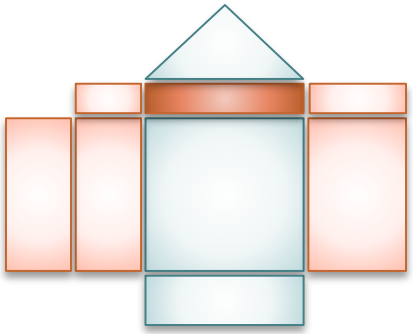


4. Competition

- ***Competition benchmarking***
  - The purpose is to determine how the customer (subjectively) perceives the competition's ability to meet each of the requirements
    - To create awareness of what already exists
    - To reveal opportunities for improvement
- For each requirement, customers rate (scale of 1 to 5)
  - All the competitors' designs
  - The existing design (if the company redesigns its current product)



	Passeng	Agent	↑ %	↑ steps	↓ N	↓ N	↓ N	↓ N	↓ sec	↑ N	↑ N
Easy positioning of seat height	4	4		⊙	⊙						
Easy to position chairs	6	10	⊙								
Minimum effort for all	15	10				⊙	⊙				
Good lifting position	10	12	○								
Minimum time for transfer	3	14		Δ					⊙		
Easy to move	7	8						⊙	⊙		○	○
Fits in aircraft aisle	-	-									
Good stability	24	10								⊙	⊙
Aisle chair close to aircraft seat	6	2	⊙								
Easy positioning of seat height	5	8		⊙	⊙						
Minimum effort for all	15	12		○	○			⊙			
Minimum transfer time	5	10		Δ					⊙		



5. Design specifications

- Translation of “the voice of the customer” into “the voice of the engineer”
- Design specifications are the restatement of the design problem in terms of parameters that ***can be measured*** (have units of measure)
- Find as many measureable parameters as possible
  - Each parameter should measure at least one customer requirement (ideally multiple requirements)
- Indicate the direction of improvement (↑ more is better and ↓ less is better)
- Target value can be indicated

Design specifications – **Example – a pen**

- Customer Need:
  - The pen writes smoothly.

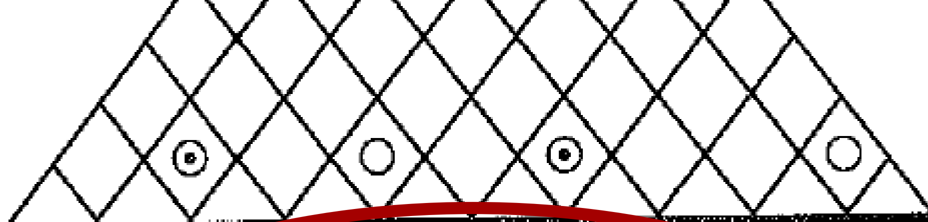
Assuming that smooth writing can be characterized by:
- Good quality line
- Preservation of line quality
- Ease of use...

- Design specifications (units)

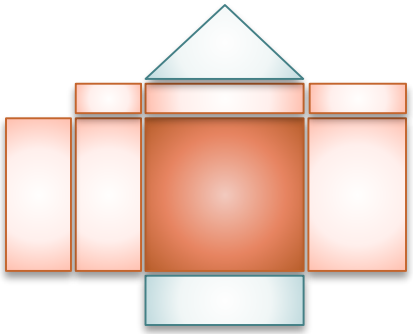
1. Variation in line thickness (mm)
2. Variation in ink coverage (cc/mm^2)
3. Functional range of writing force (N)
4. Functional range of writing velocity (mm/sec)
5. Functional range of pen angle from vertical (deg)
6. Variation in resistance to translational motion (N)

Types of engineering specifications

- Functional performance
  - Flow of energy
  - Flow of information
  - Flow of materials
  - Operational steps
  - Operation sequence
- Human factors
  - Appearance
  - Force and motion control
  - Ease of controlling and sensing state
- Physical requirements
  - Physical properties
  - Available spatial envelope
- Reliability
  - Mean time between failures
  - Safety (hazard assessment)
- Life-cycle concerns
  - Distribution (shipping)
  - Maintainability
- Life-cycle concerns (continued)
  - Diagnosability
  - Testability
  - Reparability
  - Cleanability
  - Installability
  - Retirement
- Resource concerns
  - Time
  - Cost
  - Capital
  - Unit
  - Equipment
  - Standards
  - Environment
- Manufacturing/assembly requirements
  - Materials
  - Quantity
  - Company capabilities



		Who		How										Now				
		Passenger	Agent	Seat width relative to frame width	Steps to adjust seat height	Force to adjust seat height	Force to slide 95% male passenger	Lifting force required for agent	Push force over 2 cm bump	Force to push aisle chair	Time to transfer between seats	Fore/aft tipping force at handles	Side tipping force at handles	1 = very bad 5 = very good ▶ Colub ■ Deltor				
				↑	↓	↓	↓	↓	↓	↓	↓	↑	↑					
				%	steps	N	N	N	N	N	sec	N	N	1	2	3	4	5
air on	Easy positioning of seat height	4	4		⊙	⊙									▶	■		
	Easy to position chairs	6	10	⊙												▶ ■		
	Minimum effort for	15	10				⊙	⊙							■	▶		



6. Requirements vs. specifications

- Relate customers' requirements to design specifications
- The values and symbols used:

◉ = 9 = strong relationship
◯ = 3 = medium relationship
△ = 1 = weak relationship
Blank = 0 = no relationship at all

- Ideally, each specification should measure more than one customer requirement
- Each customer requirement should have at least one specification with a strong relationship

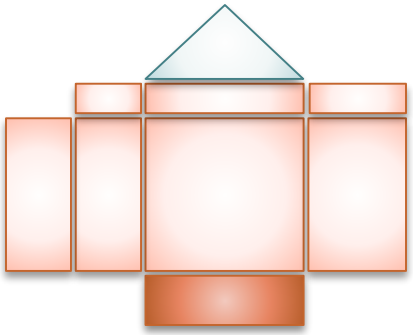
⊙ = 9
○ = 3
Δ = 1

What			Passenger	Agent	Seat width relative to frame width	Steps to adjust seat height	Force to adjust seat height	Force to slide 95% male passenger	Lifting force required for agent	Push force over 2 cm bump	Force to push aisle chair	Time to transfer between seats	Fore/aft tipping force at handles	Side tipping force at handles
					→	→	↓	↓	↓	↓	↓	↓	→	→
					%	steps	N	N	N	N	N	s	N	N
Transfer from personal to aisle chair	Aisle chair preparation	Easy positioning of seat height	4	4		⊙	⊙							
		Easy to position chairs	6	10	⊙									
	Passenger movement	Minimum effort for all	15	1				⊙	⊙					
		Good lifting position	10	12	○									
		Minimum time for transfer	3	14		Δ						⊙		
Aisle chair movement		Easy to move	7	8						⊙	⊙		○	○
		Fits in aircraft aisle	-	-										
		Good stability	24	10									⊙	⊙
Transfer from aisle chair to seat	Aisle chair preparation	Aisle chair close to aircraft seat	6	2	⊙									
		Easy positioning of seat height	5	8		⊙	⊙							
	Passenger movement	Minimum effort for all	15	12		○	○				⊙			
		Minimum transfer time	5	10		Δ						⊙		

1 = very bad
5 = very good

▸ Colub
■ Deltor

1	2	3	4	5
	▸	■		
		▸ ■		
	■	▸		
			▸	■
	▸ ■			
	■			▸
		▸	■	
	■			
	▸	■		
		▸ ■		
	▸	■		
	▸	■		



7. Targets for specifications

1. ***Specification importance***
   - Find the total value of <u>importance for each specification</u>:
     - Multiply the importance weighting from Step 3 with 0-1-3-9 relationship values from Step 6 to get the weighted values
     - Summing up all the weighted values for each specification
     - Normalize the sums across all specifications

◉ = 9 :

◯ = 3

△ = 1

7*3 + 24*9 = 237

237/1475 = **16%**

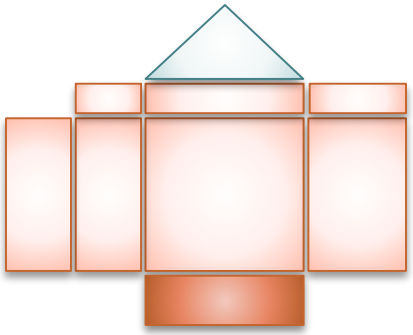
9*15 =135

135/1475 = **9%**

4*9+3*1+5*9+15*3+5*1=134

134/1475 = **9%**

at		Passenger	Agent	Seat wid… ↑ %	Steps to… ↑ steps	Force to… ↓ N	Force to… passeng… ↓ N	Lifting fo… ↓ N	Push fo… ↓ N	Force to… ↓ N	Time to… ↓ sec	Fore/aft… ↑ N	Side tip… ↑ N
chair uration	Easy positioning of seat height	4	4		◉	◉							
	Easy to position chairs	6	10	◉									
enger ement	Minimum effort for all	15	10				◉	◉					
	Good lifting position	10	12	◯									
	Minimum time for transfer	3	14		△						◉		
	Easy to move	7	8						◉	◉		◯	◯
	Fits in aircraft aisle	-	-										
	Good stability	24	10									◉	◉
chair aration	Aisle chair close to aircraft seat	6	2	◉									
	Easy positioning of seat height	5	8		◉	◉							
enger ement	Minimum effort for all	15	12		◯	◯				◉			
	Minimum transfer time	5	10		△						◉		
Importance (Passenger)		10		9	8	9	9	4	14	5	16	16	
(Agent)		11		13	11	7	7	5	14	16	8	8	
Colub		85		2	3	20	15	11	7	15	20	15	
Deltor		87		3	5	27	25	22	15	18	15	10	
Target (Delighted)		90		1	2	20	10	8	7	15	15	10	
Threshold (Disgusted)		85		2	4	25	15	12	10	18	20	12	

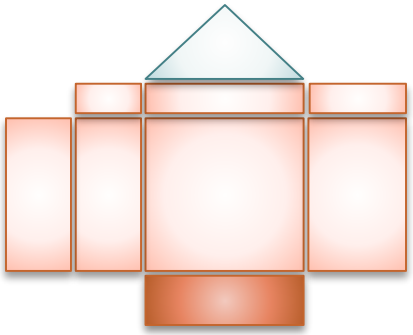


7. Targets for specifications

2. *Competition's products*

- Measure how well the competition meets your specifications
  - Obtain the samples of the competitors' products and make a measurements on them
  - Find the measurements in the literature
  - Carry out simulation studies
- A basis for <u>establishing the targets</u>

at		Passenger	Agent	Seat wi… ↑ %	Steps to… ↑ steps	Force to… ↓ N	Force to… passeng… ↓ N	Lifting f… ↓ N	Push fo… ↓ N	Force to… ↓ N	Time to… ↓ sec	Fore/aft… ↑ N	Side tip… ↑ N
chair ıration	Easy positioning of seat height	4	4		⊙	⊙							
	Easy to position chairs	6	10	⊙									
enger ement	Minimum effort for all	15	10				⊙	⊙					
	Good lifting position	10	12	○									
	Minimum time for transfer	3	14		Δ						⊙		
	Easy to move	7	8						⊙	⊙		○	○
	Fits in aircraft aisle	-	-										
	Good stability	24	10									⊙	⊙
chair aration	Aisle chair close to aircraft seat	6	2	⊙									
	Easy positioning of seat height	5	8		⊙	⊙							
enger ement	Minimum effort for all	15	12		○	○				⊙			
	Minimum transfer time	5	10		Δ						⊙		
Importance (Passenger)				10	9	8	9	9	4	14	5	16	16
	(Agent)			11	13	11	7	7	5	14	16	8	8
Colub				85	2	3	20	15	11	7	15	20	15
Deltor				87	3	5	27	25	22	15	18	15	10
Target (Delighted)				90	1	2	20	10	8	7	15	15	10
Threshold (Disgusted)				85	2	4	25	15	12	10	18	20	12

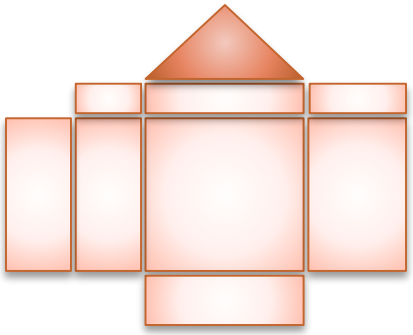


7. Targets for specifications

3. *Setting specification targets*

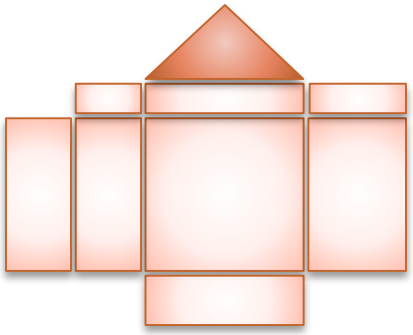
- Setting targets <u>early</u> in the design is important
  - May have +/- 30 % tolerance
  - Can be refined later
- **Single value target** – if the target is not flexible
- **Two target values** – determines the range for trade-offs
  - The ideal value - the actual target (delighted customer)
  - The marginal value - the acceptable threshold (disgusted customer)
- The target values that are very different from the competitors' should be questioned!

at		Passenger	Agent	Sea	Ste	For	For pas	Lift	Pus	For	Tim	Fo	Sid
				↑	↑	↓	↓	↓	↓	↓	↓	↑	↑
				%	steps	N	N	N	N	N	sec	N	N
chair ıration	Easy positioning of seat height	4	4		⊙	⊙							
	Easy to position chairs	6	10	⊙									
enger ement	Minimum effort for all	15	10				⊙	⊙					
	Good lifting position	10	12	○									
	Minimum time for transfer	3	14		Δ						⊙		
	Easy to move	7	8						⊙	⊙		○	○
	Fits in aircraft aisle	-	-										
	Good stability	24	10									⊙	⊙
chair aration	Aisle chair close to aircraft seat	6	2	⊙									
	Easy positioning of seat height	5	8		⊙	⊙							
enger ement	Minimum effort for all	15	12		○	○				⊙			
	Minimum transfer time	5	10		Δ						⊙		
Importance (Passenger)				10	9	8	9	9	4	14	5	16	16
(Agent)				11	13	11	7	7	5	14	16	8	8
Colub				85	2	3	20	15	11	7	15	20	15
Deltor				87	3	5	27	25	22	15	18	15	10
Target (Delighted)				90	1	2	20	10	8	7	15	15	10
Threshold (Disgusted)				85	2	4	25	15	12	10	18	20	12



8. Relationships between specifications

- Correlations between the specifications
- Improving one specification may have negative/positive impact on the other ones
- Specifications in the ideal world are independent
  - However, the designed should welcome if the specifications are correlated! Using correlated variables for specifications gives designers the freedom to find the way by which they achieve the specifications. Independent variables suggest the solution and reduce the space for finding creative solution.



8. Relationships between specifications

- Possible use of the symbols:
  - **+** the improvement of one will improve the other one

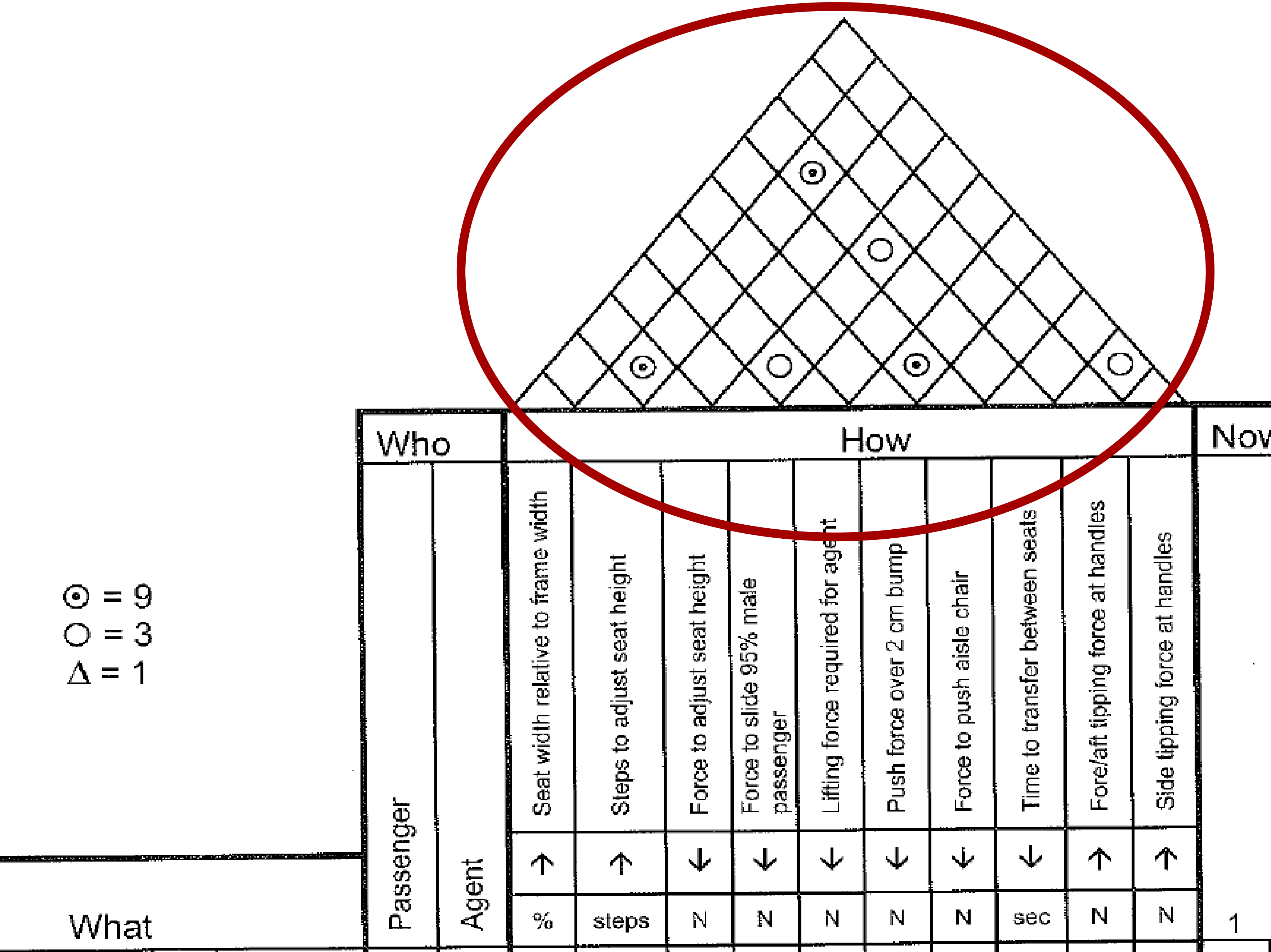
    - the improvement of one will harm the other one

  - The same symbols as in Step 6:

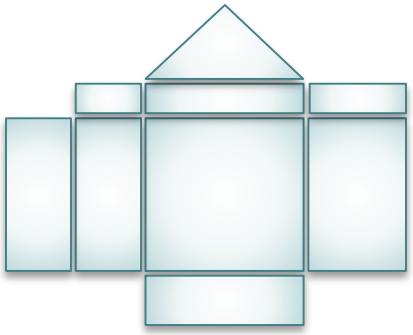
    ◉ strong relationship

    ○ medium relationship

    △ weak relationship



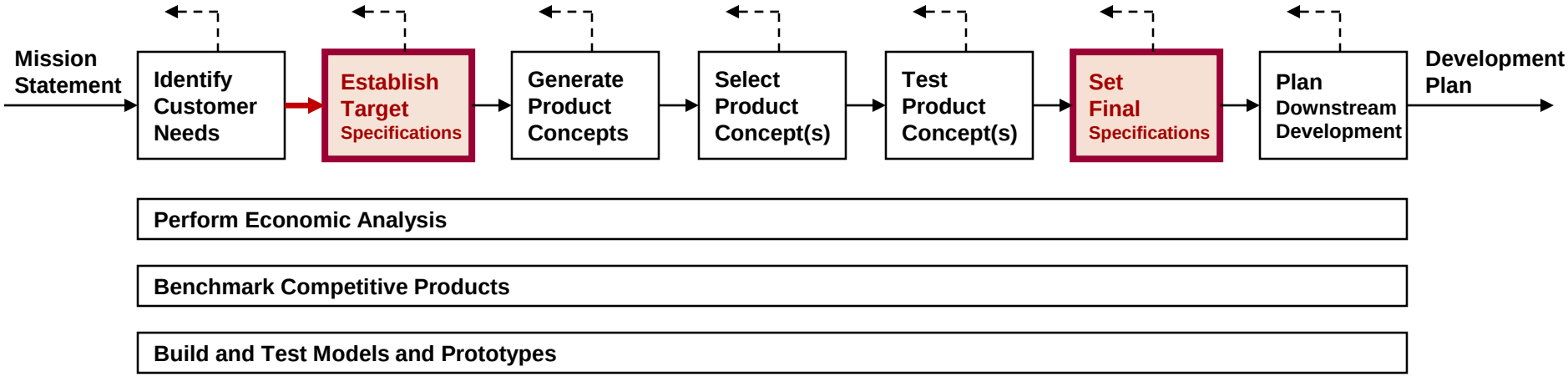
⊙ = 9
○ = 3
Δ = 1
Who
How
Now
Passenger
Agent
What
Seat width relative to frame width
Steps to adjust seat height
Force to adjust seat height
Force to slide 95% male passenger
Lifting force required for agent
Push force over 2 cm bump
Force to push aisle chair
Time to transfer between seats
Fore/aft tipping force at handles
Side tipping force at handles
↑ ↑ ↓ ↓ ↓ ↓ ↓ ↓ ↑ ↑
% steps N N N N N sec N N
1



QFD – final comments

- QFD ensures that the problem is well understood
- It may appear slow, but time is more than recovered later in the design process
- More complex problems can be decomposed into several loosely dependent houses of quality
- QFD is a working document and should be updated as needed

Concept Development Process



Setting the final specifications

- The established specifications will be revisited later – at the end of the Concept Development phase
- The specifications are established twice:
  - *Target specifications (*after customer needs)
  - *Final specifications (*after concept selection)
- Finalizing the specifications is difficult because of ***trade offs*** (inverse relationships between two specifications):
  - Between different technical performance metrics
    - Technical models of the product
  - Between technical performance metrics and cost
    - Cost models of the product

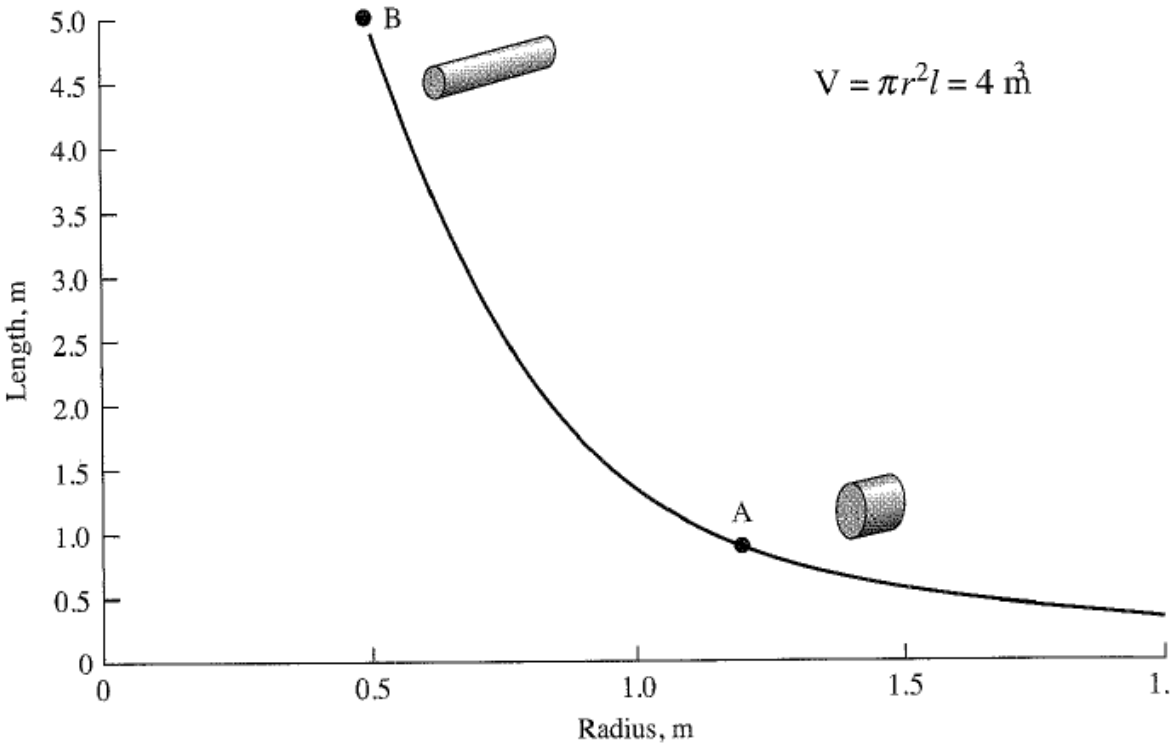
Setting the final specifications

Technical models of the product

- ***Technical model of the product*** is a tool for predicting the values of the metrics (specifications) for a particular set of design decisions
  - Performed after the concept is selected!
- The goal:
  - Explore different combinations of design variables
  - Determine the feasibility of any particular set of specifications
- Several independent models are better than one large integrated model
- Design of Experiments (DOE) can be useful

Setting the final specifications

Technical trade-off



Trade off for the design of a tank to hold $4m^3$ of liquid.
Customer wants a tank which is *short* and *thin*.

Setting the final specifications

Cost model of the product

- The goal of a cost model is to make sure that the product can be produced at a target cost
  - ***Target cost*** is the manufacturing cost at which the company and its distribution partners can make adequate profits while still offering the product to the end customer at a competitive price
- ***Bill of materials*** is a list of all the parts
  - May serve as a preliminary cost model by including cost estimates (purchase or fabrication cost for each part)
  - A useful way is to include the high and low estimates of each item
  - All the parts still may not be known

Setting the final specifications

Cost model of the product – Bill of materials

Component	Qty/ Fork	High ($ ea.)	Low ($ ea.)	High Total ($/fork)	Low Total ($/fork)
Steertube	1	2.50	2.00	2.50	2.00
Crown	1	4.00	3.00	4.00	3.00
Boot	2	1.00	0.75	2.00	1.50
Lower tube	2	3.00	2.00	6.00	4.00
Lower tube top cover	2	2.00	1.50	4.00	3.00
Main lip seal	2	1.50	1.40	3.00	2.80
Slide bushing	4	0.20	0.18	0.80	0.72
Slide bushing spacer	2	0.50	0.40	1.00	0.80
Lower tube plug	2	0.50	0.35	1.00	0.70
Upper tube	2	5.50	4.00	11.00	8.00
Upper tube top cap	2	3.00	2.50	6.00	5.00
Upper tube adjustment knob	2	2.00	1.75	4.00	3.50
Adjustment shaft	2	4.00	3.00	8.00	6.00
Spring	2	3.00	2.50	6.00	5.00
Upper tube orifice cap	1	3.00	2.25	3.00	2.25
Orifice springs	4	0.50	0.40	2.00	1.60
Brake studs	2	0.40	0.35	0.80	0.70
Brake brace bolt	2	0.25	0.20	0.50	0.40
Brake brace	1	5.00	3.50	5.00	3.50
Oil (liters)	0.1	2.50	2.00	0.25	0.20
Misc. snap rings, o-rings	10	0.15	0.10	1.50	1.00
Decals	4	0.25	0.15	1.00	0.60
Assembly at $20/hr		30 min	20 min	10.00	6.67
Overhead at 25% of direct cost				20.84	15.74
Total				$104.19	$78.68

Setting the final specifications

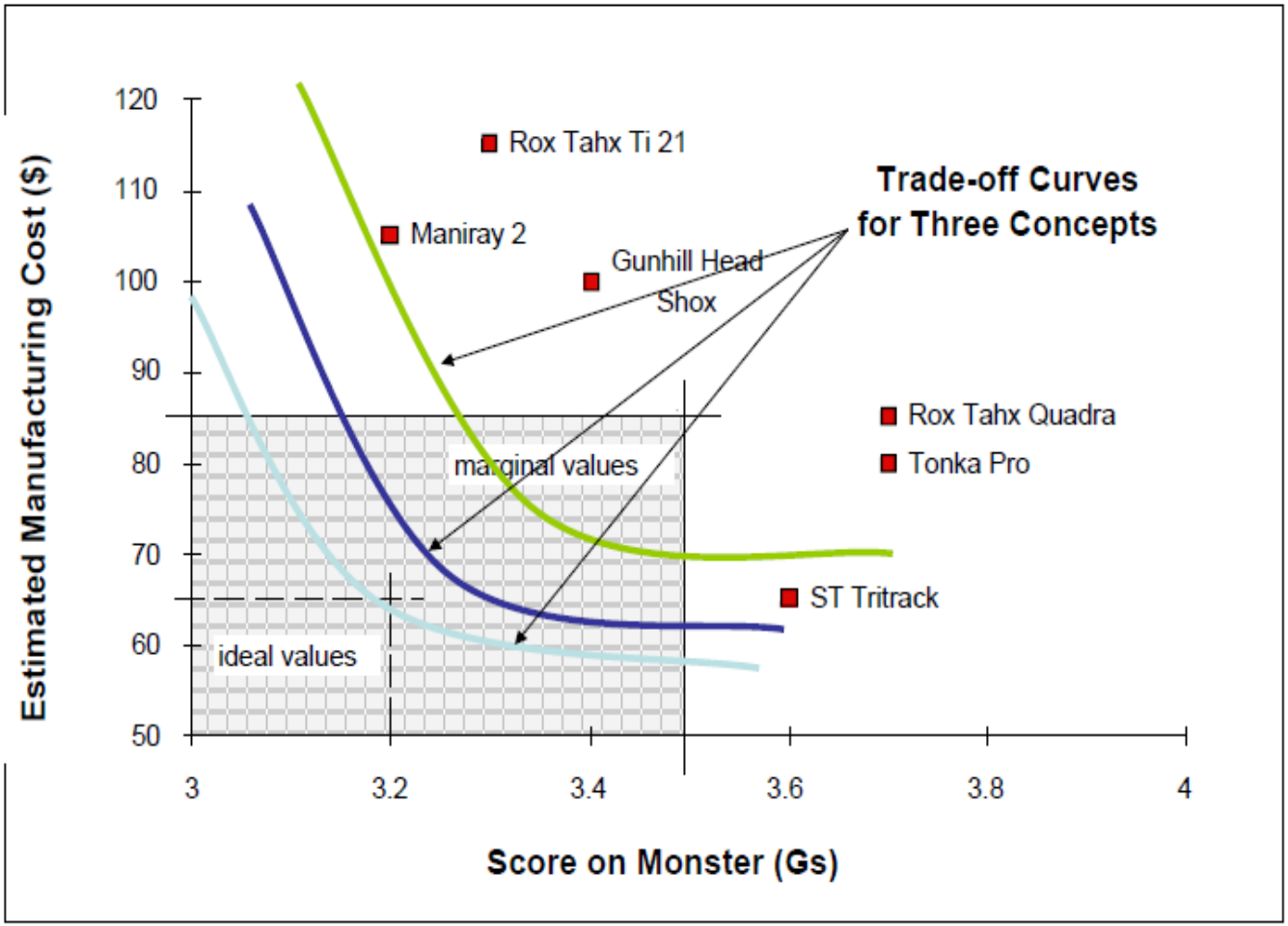
Refining the specifications

- Specifications which will position the product best relative to the competition, which will best satisfy the customer needs and will ensure adequate profits

- ***Competitive map*** (trade-off map)
  - Positions the new product relative to the competition
  - Based on the benchmarking data generated during the QFD process (Step 7.2)

Setting the final specifications

Refining the specifications – Competitive map



Setting the final specifications

Refining the specifications – Competitive map