Problem Understanding

MCHE 201 – Spring 2019

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Phases of Design

1. Problem Understanding
2. Specification Development
3. Conceptual Design

} What we'll talk about. The most nonlinear part.

4. Detail Design
5. Production Specification

} Machine Design

6. Manufacture
7. Disposal

The entire process is iterative.

Phases of Design

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What we'll talk about.

The most nonlinear part.

Machine Design

The entire process is iterative.

Understand, *then* Design & Build

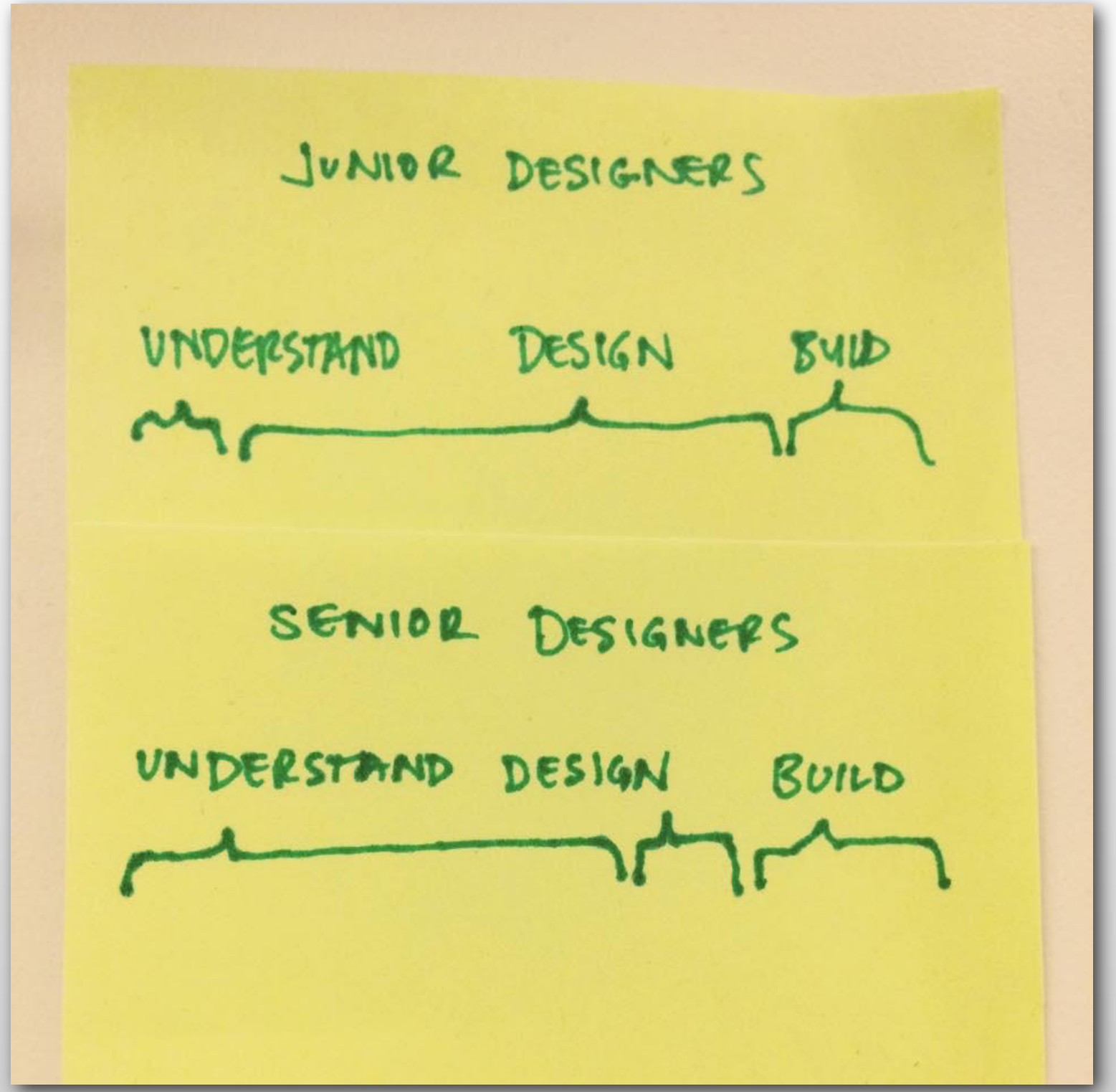


Image from: https://twitter.com/dburka/status/555496843920961536/photo/1

Problem Understanding

- Who is the customer?
  - end-user?
  - reseller?
  - sales team?
  - ...???

} Who *are* the *customers*?

- These customers *will* have some conflicting needs/ demands

- These customers will *not* do a good job telling you what they *really* want

Quality Function Deployment

- 1988 Harvard Business Review article
- Developed from study of Kobe Shipyards

Design is a team effort, but how do marketing and engineering talk to each other?

The House of Quality

by John R. Hauser and Don Clausing

Digital Equipment, Hewlett-Packard, AT&T, and ITT are getting started with it. Ford and General Motors use it–at Ford alone there are more than 50 applications. The "house of quality," the basic design tool of the management approach known as quality function deployment (QFD), originated in 1972 at Mitsubishi's Kobe shipyard site. Toyota and its suppliers then developed it in numerous ways. The house of quality has been used successfully by Japanese manufacturers of consumer electronics, home appliances, clothing, integrated circuits, synthetic rubber, construction equipment, and agricultural engines. Japanese designers use it for services like swimming schools and retail outlets and even for planning apartment layouts.

A set of planning and communication routines, quality function deployment focuses and coordinates skills within an organization, first to design, then to manufacture and market goods that customers want to purchase and will continue to purchase. The foundation of the house of quality is the belief that products should be designed to reflect customers' desires and tastes–so marketing people, design engineers, and manufacturing staff must work closely together from the time a product is first conceived.

The house of quality is a kind of conceptual map that provides the means for interfunctional planning and communications. People with different

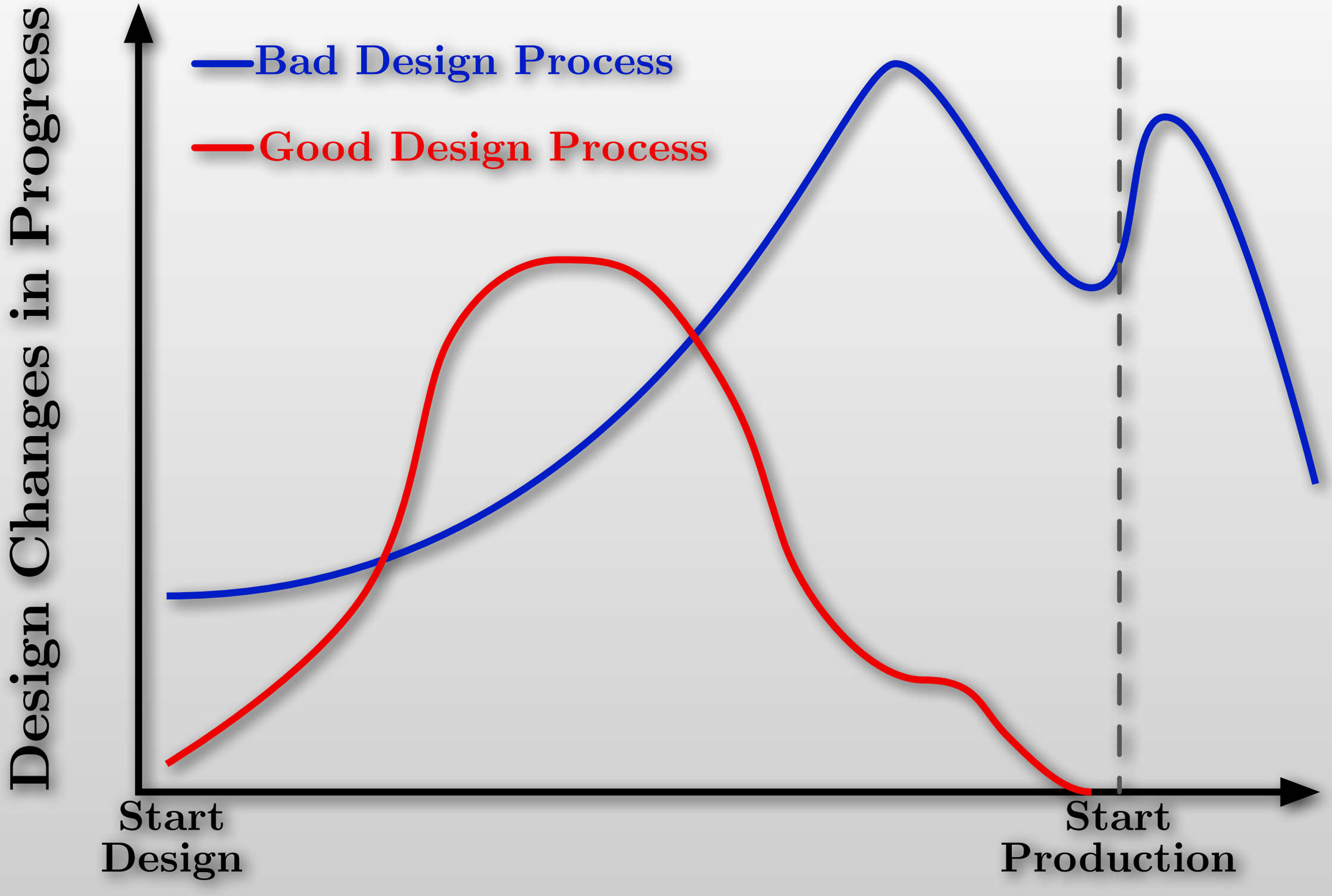
John R. Hauser, at the Harvard Business School as a Marvin Bower fellow during the current academic year, is professor of management science at MIT's Sloan School of Management. He is the author, with Glen L. Urban, of Design & Marketing of New Products *(Prentice-Hall, 1980). Don Clausing is Bernard M. Gordon Adjunct Professor of Engineering Innovation and Practice at MIT. Previously he worked for Xerox Corporation. He introduced QFD to Ford and its supplier companies in 1984.*

HARVARD BUSINESS REVIEW May-June 1988

Quality Function Deployment (QFD)

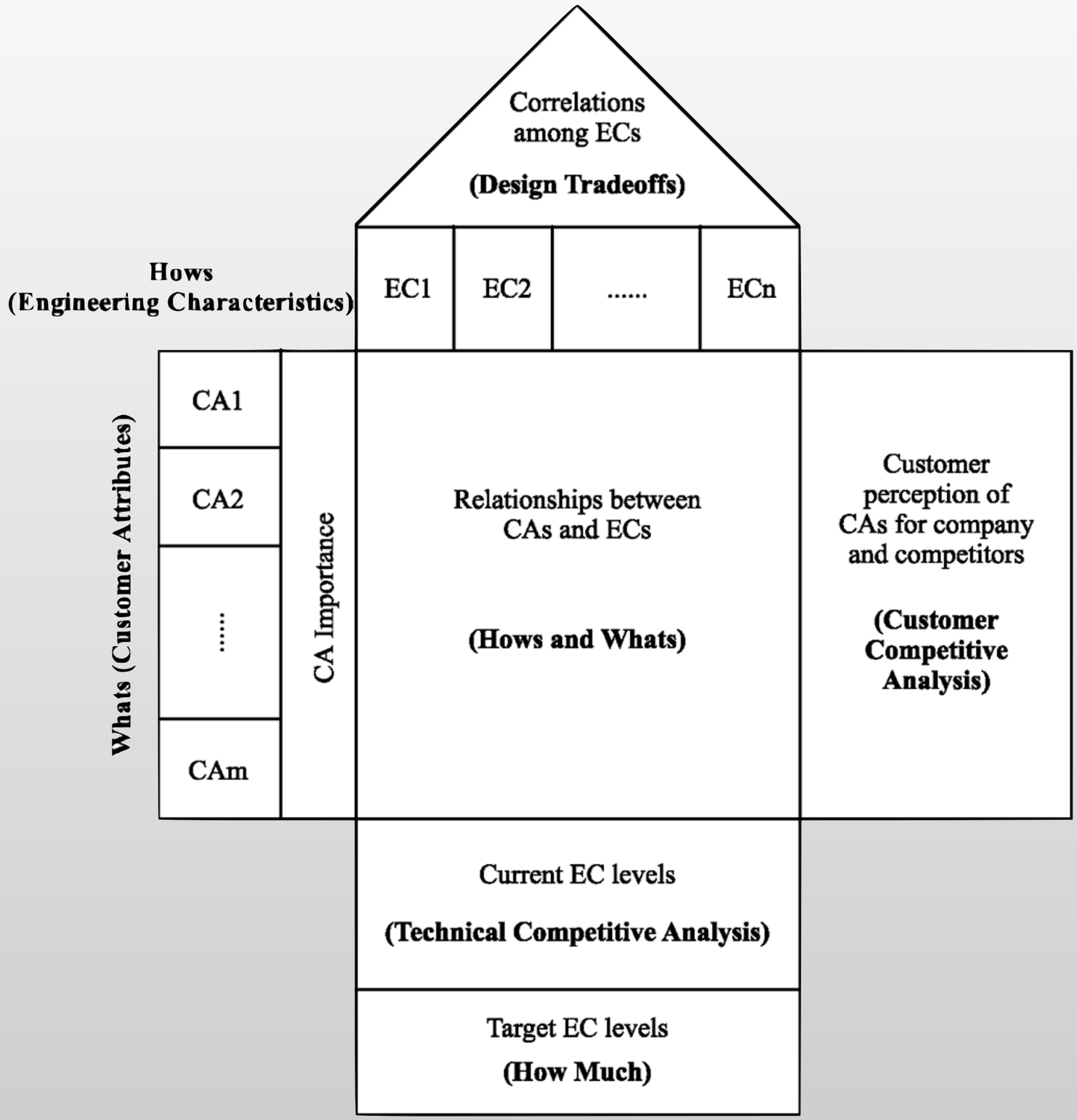
- QFD is a planning tool
  - Customer Needs → Product Dev. Requirements
  - Establishes where time and effort should be focused
  - Establishes where time and effort should ***not*** be focused
- QFD in *not* quality control

Design Change Comparison



The House of Quality

- A lot of the utility is completing the tool
- A "living" document

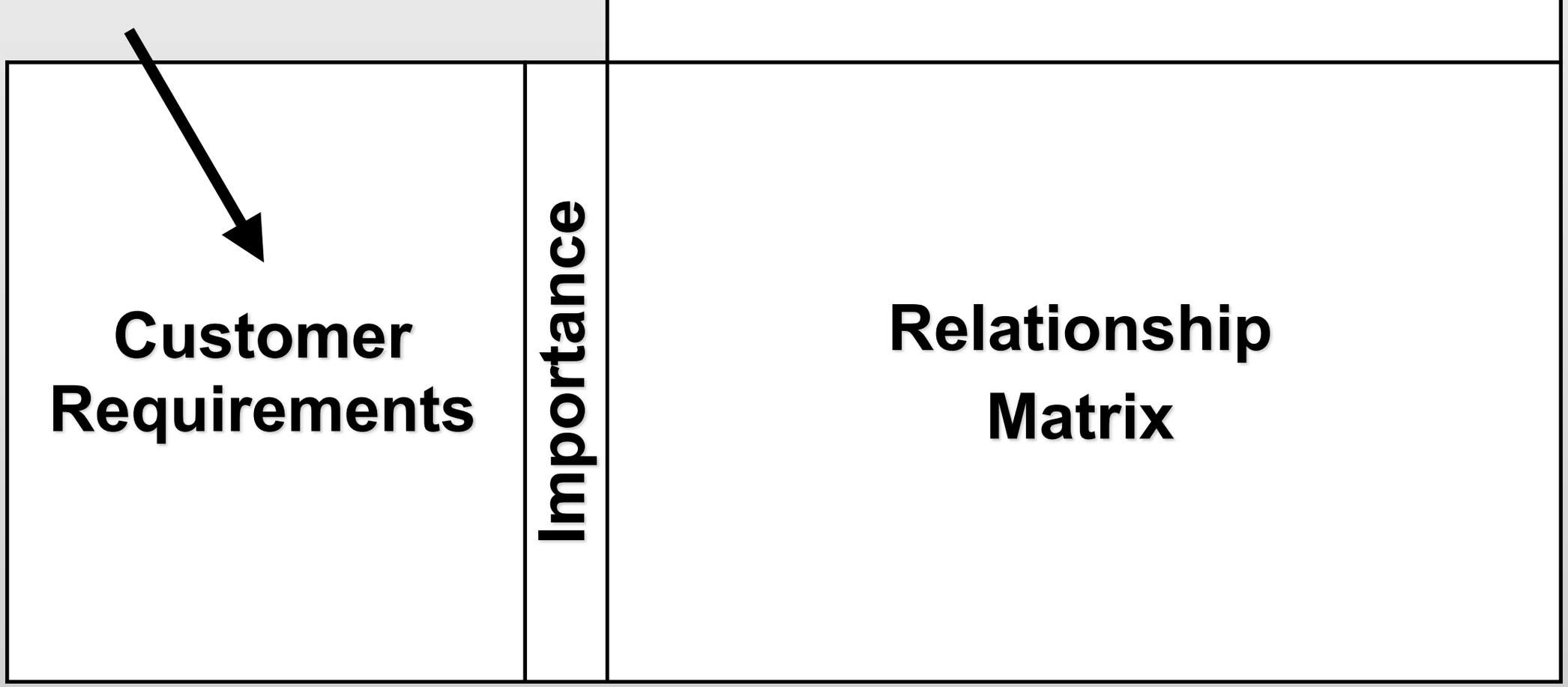


The Problem Understanding Form

The “middle” of the House of Quality

Measurable **characteristics of the design.**

Your understanding of what your customer wants.



The Problem Understanding Form

The “middle” of the House of Quality

Measurable **characteristics of the design.**

Your understanding of what your customer wants.

		Engineering Characteristics
Customer Requirements	**Importance**	**How do the measurable characteristics of the design relate to what the customer requirements?**

The Problem Understanding Form

◉	Strong = 9
▣	Medium = 3
△	Weak = 1

Customer Requirements	Importance	Engineering Characteristics				
		◉				

The Problem Understanding Form

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Customer Requirements	Importance	Engineering Characteristics				
		◉		▣	△	

The Problem Understanding Form

◉	Strong = 9
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		Engineering Characteristics				
		◉		▣	△	
Customer Requirements	Importance					

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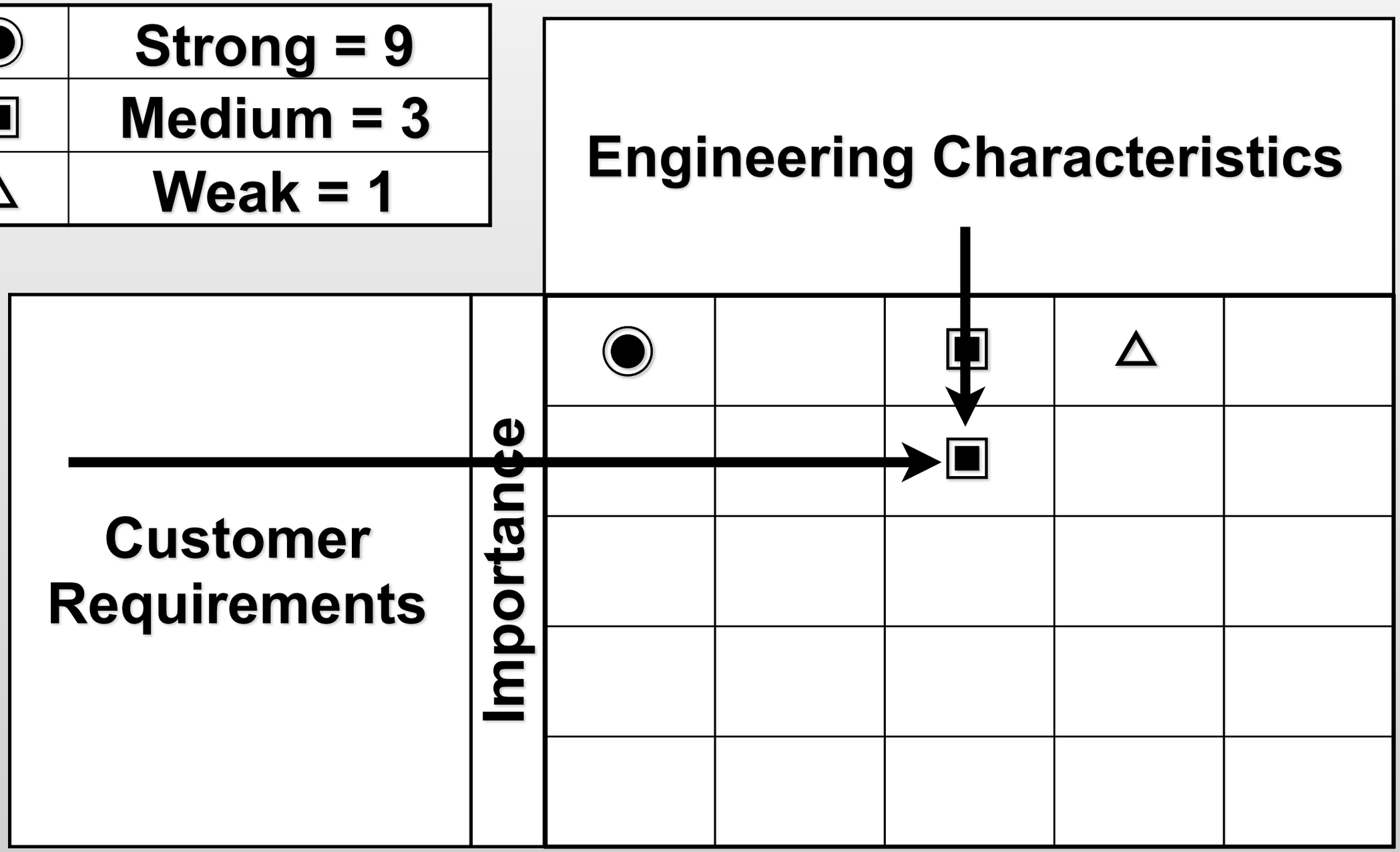

The Problem Understanding Form

◉	Strong = 9
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Customer Requirements	Importance	Engineering Characteristics				
		◉		▣	△	
			◉	▣		▣
		◉	▣		△	
		▣	△			▣
			◉	△	◉	△

Using the House of Quality

- Look for:
  - Blank rows

The Problem Understanding Form

◉	Strong = 9
▣	Medium = 3
△	Weak = 1

Customer Requirements	Importance	Engineering Characteristics				
		◉		▣	△	
Empty Rows are a Problem						
		◉	▣		△	
		▣	△			▣
			◉	△	◉	△

Using the House of Quality

- Look for:
  - Blank rows

Customer Need is not being addressed

  - Blank columns

The Problem Understanding Form

◉	Strong = 9
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Customer Requirements	Importance	Engineering Characteristics				
		◉		▣	△	
			◉	▣		
		◉	▣		△	
		▣	△			
			◉	△	◉	

Empty Cols. are a Problem

Using the House of Quality

- Look for:
  - Blank rows ← **Customer Need is not being addressed**
  - Blank columns ← **Addressing a Customer Need that does not exist**

The Problem Understanding Form

◉	Strong = 9
▣	Medium = 3
△	Weak = 1

		Engineering Characteristics				
Customer Requirements	5	◉		▣	△	
	6		◉	▣		▣
	9	◉	▣		△	
	2	▣	△			▣
	1		◉	△	◉	△

Technical Importance(s)

- We can get numbers
- Do not use *only* the numbers as justification for design decisions!
- Absolute Importance – Sum along a column

$$\sum_{\text{col}} (\text{relationship ranking} \times \text{customer importance})$$

- Relative Importance – Absolute importance of Eng. Char ÷ Sum of absolute importances

$$\sum_{\text{char.}} \frac{\text{Absolute Importance}}{\sum(\text{Absolute Importances})}$$

The Problem Understanding Form

◉	Strong = 9
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		Engineering Characteristics				
Customer Requirements	5	◉		▣	△	
	6		◉	▣		▣
	9	◉	▣		△	
	2	▣	△			▣
	1		◉	△	◉	△
Absolute Importance		132				

5*9 + 9*9 + 2*3 = 132

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		Engineering Characteristics					
Customer Requirements	5	◉		▣	△		
	6		◉	▣		▣	
	9	◉	▣		△		
	2	▣	△			▣	
	1		◉	△	◉	△	sum
Absolute Importance		132	92	34	17	25	300

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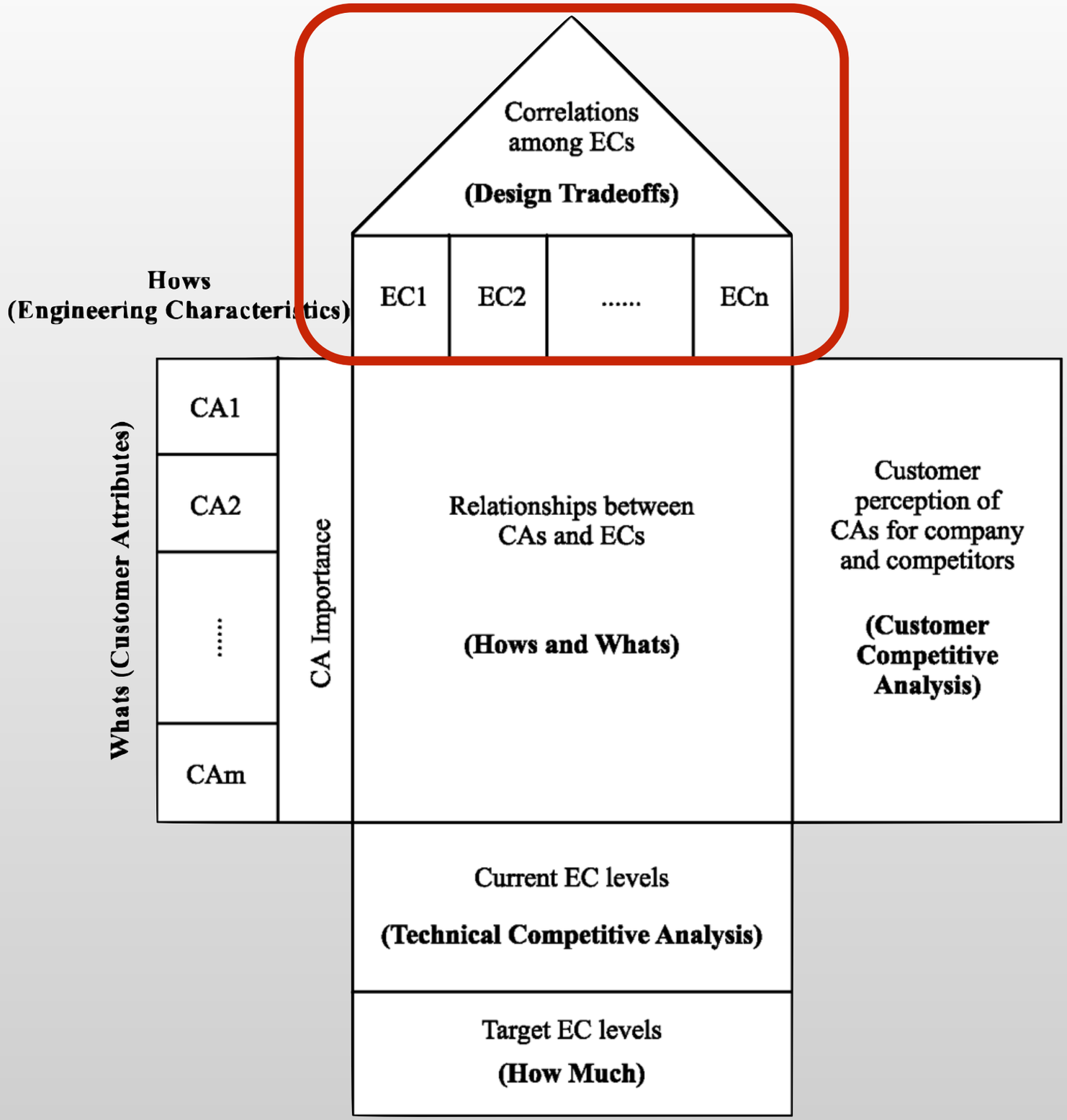
		Engineering Characteristics					
Customer Requirements	5	◉		▣	△		
	6		◉	▣		▣	
	9	◉	▣		△		
	2	▣	△			▣	
	1		◉	△	◉	△	
Absolute Importance		132	92	34	17	25	sum 300
Relative Importance		0.44	0.31	0.11	0.06	0.08	

HoQ Exercise – For a Spaghetti Tower

- Identify the customer(s), then

- List the:
  - Customer Requirements
  - Engineering Characteristics

The HoQ Correlation Matrix

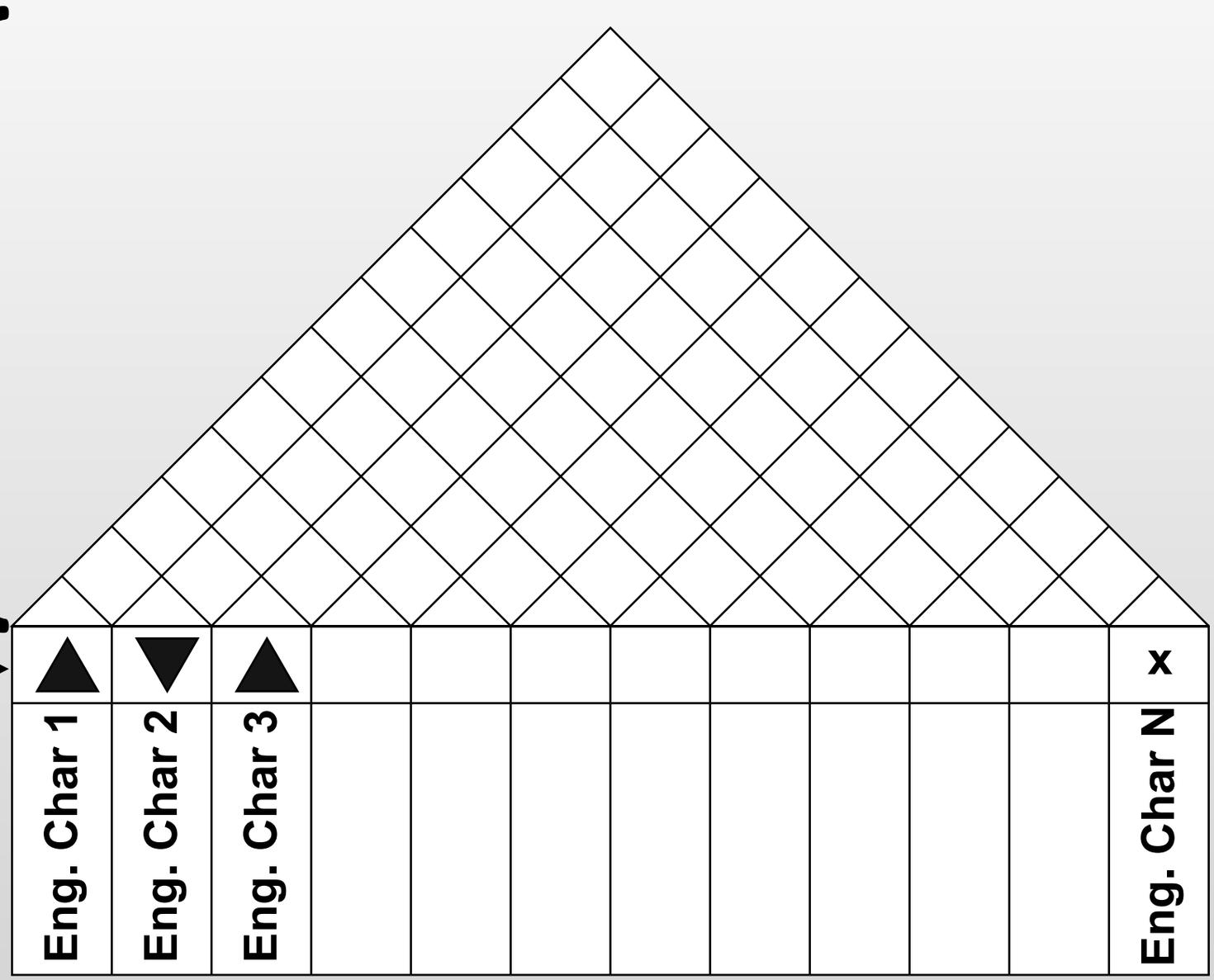


The HoQ Correlation Matrix

How does improving toward the goal for one char. affect our ability to improve toward the goal for others?

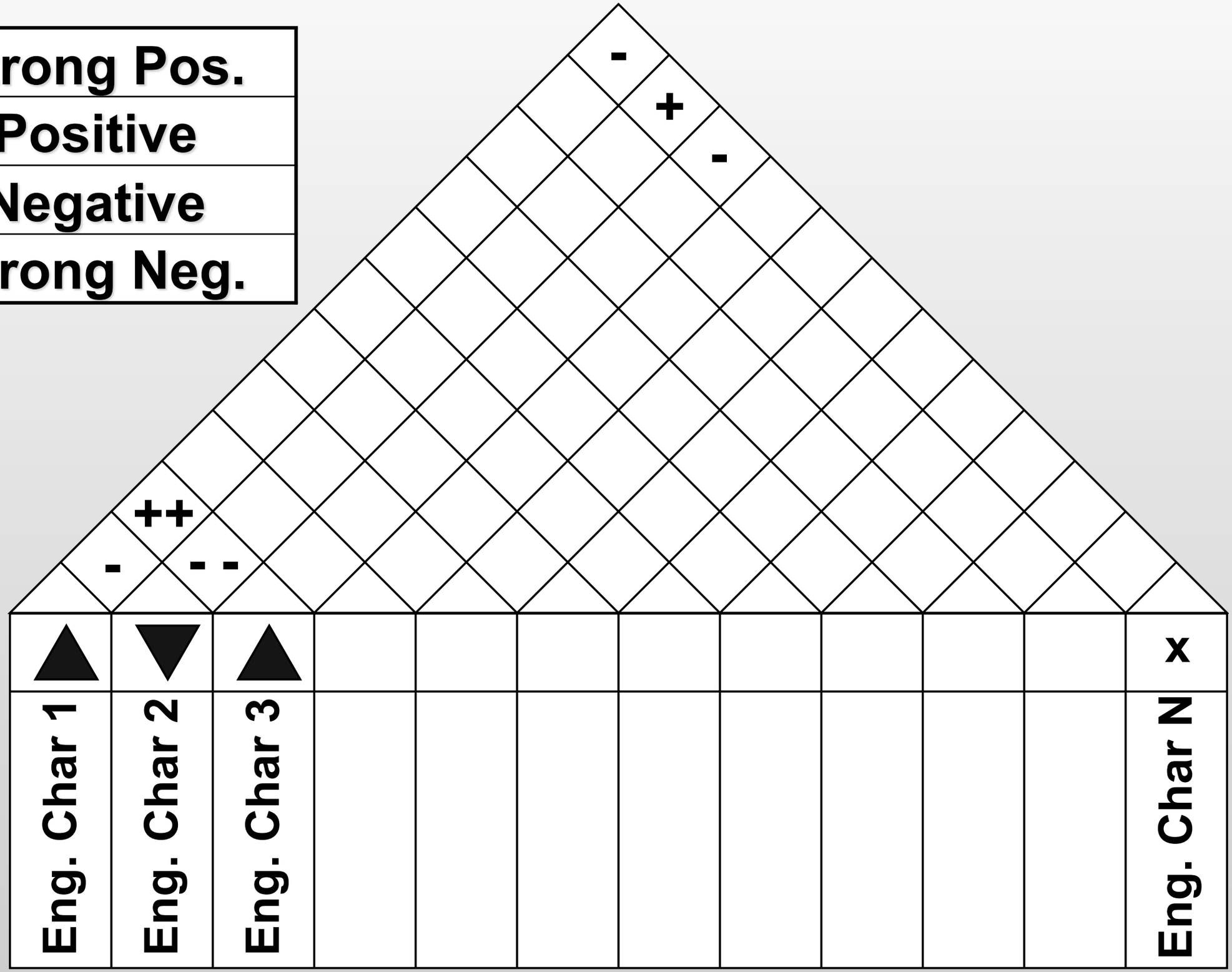
Goal:

Maximize – ▲
Minimize – ▼
Meet Target – x



The HoQ Correlation Matrix

++	Strong Pos.
+	Positive
-	Negative
- -	Strong Neg.



House of Quality Tips/Hints

- *Explicitly* identify your customers
- List every thing any of your customers care about
- Take each point of that list and expand
  - What does this *really* mean?
  - What does the customer *really* want?
    - *e.g.* Reliable?… Uptime of 99.99%? Can survive misuse?
    - *e.g.* Easy to use?… Low number of steps? Easily understandable process? Low physical effort needed?
- For each customer requirement, determine what you could measure to determine if you are satisfying it or not. These are (the start of) the Engineering Characteristics.
- Revisit regularly as your understanding of the problem improves!!!

Design Specifications

- Translation of customer requirements into engineering specifications

- *Numerical* targets or constraints that *all* possible concepts must meet

- Derived from:
  - Standards
  - Engineering characteristics in House of Quality
  - Engineering analysis

Design Specification Categories

- Geometric
- Kinematics
- Dynamics
- Energy
- Costs
- Material
- Signals
- Safety
- Ergonomics
- Schedules
- Assembly
- Transportation
- Operation
- Quality Control
- Recycling

The Spec. Sheet

		For: **PRODUCT NAME**	**Issued:** mm/dd/yy	
			Page x of N	
Changes	**D/W**	**Requirements**	**Resp.**	**Source**

The Spec. Sheet

		For: **PRODUCT NAME**	**Issued:** mm/dd/yy	
			Page x of N	
Changes	**D/W**	**Requirements**	**Resp.**	**Source**
Date of last change.	**Demand or Wish?**	**Requirements, sorted by category.**	**Who is responsible?**	**What is the source of this requirement?**

Spec. Sheet Tips/Hints

- Take every Eng. Char. and define numerical targets
  - Uptime ➞ Uptime > 99.99%
  - Time between required maintenance ➞ Maintenance <1 time per year
  - Number of assembly steps ➞ Number of assembly steps <15
  - Top speed ➞ Top speed > 160mph
  - Max. Acceleration ➞ 0-60mph time < 3s
  - Battery life in hours at 75% load ➞ >5 hour life at 75% load
  - “Average” user time between charges ➞ >1 day between charges in normal use
- Determine if each is a demand or wish/want
- For every demand, are there accompanying specs. that are wishes/wants?
- Revisit regularly as your understanding of the problem improves!!!