Introduction to Problem Understanding Tools

Christopher Saldana, Ph.D.

Woodruff School of Mechanical Engineering
Georgia Institute of Technology
Atlanta, Georgia, USA
Video - iPhone 11
What is design?

“Engineering design is the systematic process of generating, evaluating and specifying concepts that meet constraints and needs”

What is creativity?

“Creativity... is the ability to look at the problem in a different way or to restructure the wording of the problem such that new and previously unseen possibilities arise”

Design Methods and Types

Humans create via:
• Synthesis – combining and recombining parts – old ideas or concepts re-made
• Analogizing – transferring working principles

Types of design:
• Original – new products, new ideas (patents)
• Adaptive – known system to a changed task
• Variant – vary size/arrangement, same task
• Redesign – adaptive & variant (bulk of work)
Product Evolution

HOME AUDIO SYSTEM

Home audio systems transitioned from ornate wooden designs to compact, unobtrusive designs.

1900s
Victor Victrola Talking Machine

1910s
Edison’s Disc Phonograph Cabinets

1920s
Victrola Portable

1930s
Zenith Z1000 Stratosphere

1940s
Admiral Home Entertainment System

1950s
Harman Kardon Festival TA230

1960s
8-Track Home Deck

1970s
Advent Model 200

1980s
JVC RC-M90 “Boombox”

1990s
Sony SCD-1 CD Player

2000s
Sonos ZP100

2010s
Smart Speakers

NeoMam Studios, 2018.
Product Evolution

VACUUM CLEANER

Since their inception, vacuum cleaners have evolved to be smaller and more portable, with the goal of making cleaning easier.

1900s
- Hoover Model 0

1920s
- Hoover 700

1940s
- Electrolux Z36

1960s
- The Hoover Constellation

1980s
- Cyclone

2000s
- Roomba

1910s
- The Royal Standard

1930s
- Hoover Model 150

1950s
- The Hamilton Beach Model 14

1970s
- Interstate Engineering Corporation's Model C-8

1990s
- Dyson DC01 Bagless ‘Hoover’

2010s
- Dyson 360 Eye

NeoMam Studios, 2018.
Product Evolution

TELEPHONE

Phones evolved to be smaller and lighter, until going fully mobile with the creation of cell phones.

1900s
Strawger Candlestick Phone

1920s
Kellogg Dial Grabaphone

1940s
Western Electric 500

1960s
The Trimline

1980s
AT&T Cordless Telephone 4400

2000s
iPhone

1910s
Model 50AL Candlestick

1930s
Western Electric 302

1950s
The Princess

1970s
Novelty Phones

1990s
Nokia 1610

2010s
iPhone X

NeoMam Studios, 2018.
Product Evolution

HEADPHONES

Headphones evolved from bulky over-ear speakers to nearly invisible buds, as the technology focused on music.

1900s
Electrophone

1920s
Brando Superior

1940s
AKG K120 DYN

1960s
Koss ESP-6

1980s
Walkman Headphone

2000s
iPod Earbuds

1910s
Baldy Phones

1930s
Ericsson Headphones

1950s
Koss SP3 Stereophones

1970s
Sennheiser HD414

1990s
Sony MDR-G61

2010s
Apple AirPods

NeoMam Studios, 2018.
General approaches to design

Novice designer
- Trial and error
- Start solving immediately

Experienced designer
- Use of design strategies
- Keep options open
- Aware of tradeoffs / limitations
- Refer to past designs
- Technological investigation
- Frame and reframe the problem

Case Example 1: Automated Page Turner

**Background:** Students at the Rosedale School have limited dexterity. The Rosedale library has an existing page-turning design that receives 10-12 hours of use a week for students reading books.

**Objective:** The design team’s goal is to design and manufacture an improved device that does not damage books, operates consistently well, and is easier to load with books.
Case Example 1: Automated Page Turner

- 50+ patents
- 20+ Analogous Devices
- Different types of users and needs
- Cost and/or Performance Issues
- Variable book forms
Case Example 1: Automated Page Turner

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>GEWA BLV-6</td>
<td>Automatic</td>
<td>Disabilities</td>
<td>Yes</td>
<td>Yes</td>
<td>Joystick, various switches, Remote</td>
</tr>
<tr>
<td>Touch Turner</td>
<td>Automatic</td>
<td>Disabilities</td>
<td>Yes</td>
<td>Yes</td>
<td>Joystick, various switches</td>
</tr>
<tr>
<td>Turn Mate</td>
<td>Automatic</td>
<td>Music</td>
<td>No</td>
<td>No</td>
<td>Foot pedal</td>
</tr>
<tr>
<td>Kirtas BookScan Products</td>
<td>Automatic</td>
<td>Digital Books</td>
<td>Yes</td>
<td>Yes</td>
<td>None</td>
</tr>
<tr>
<td>Grover Gear Products</td>
<td>Manual</td>
<td>Disabilities</td>
<td>Yes</td>
<td>Yes</td>
<td>Hand control</td>
</tr>
<tr>
<td>Hand Held Page Turners</td>
<td>Manual</td>
<td>Disabilities</td>
<td>Yes</td>
<td>Yes</td>
<td>Hand control</td>
</tr>
</tbody>
</table>
Phases of Design

Customer
• Understand the Design Process

Specification Development
• Specification of Information

Conceptual Design
• Specification of a Principle
• Functional Decomposition
• Generate Concepts
• Concept Evaluation
• Concept Selection
• Preliminary Design/Embodiment

Detail Design
Specification of Production
• Process Planning

Manufacture
Quality Function Deployment and Specifications

Christopher Saldana, Ph.D.

Woodruff School of Mechanical Engineering
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Learning Objectives

Identify types of customers

Identify and interpret customer needs

Define engineering requirements

Translate customer needs to engineering requirements using a house of quality (HOQ)

Use a HOQ to show relationships among customer needs and engineering requirements

Create a specifications list from engineering requirements and customer needs
Video – B787 Cabin
Video – B787 Operators
Who is the Customer for this System?

- airlines
- passengers
- flight attendants
- pilots
- ground crew
- TSA
- air traffic control
- FAA
- and many others....
Three Types of Quality/Features

Basic:
• Expected of assumed
• Typical of “invisible” products
• Functions of products

Performance:
• One dimensional
• Most market research

Excitement:
• Pleasant surprises or customer delights
• Unexpected

Adapted From the Kano Model
Customer needs are found by asking, observing, and testing

- Focus Groups
- One-on-One Interviews
- Lead Users
- Articulated Use Interviews
- Ethnography
- Empathic design
- Many others...

https://www.coolcamping.co.uk/features/35-the-rise-rise-of-inflatable-tents

Customer needs are specific, positive, and solution-neutral (ish)

<table>
<thead>
<tr>
<th>Guideline</th>
<th>Customer Statement</th>
<th>Need Statement</th>
<th>Need Statement</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Wrong</strong></td>
<td><strong>Right</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>What Not How</strong></td>
<td>“Why don’t they put a hook at the end of the outlet hose?”</td>
<td>The outlet hose has a hook to connect to water containers.</td>
<td>The WF easily transfers water into a variety of different containers</td>
</tr>
<tr>
<td><strong>Specificity</strong></td>
<td>“I often times drop the water filter on rocks.”</td>
<td>The WF is rugged.</td>
<td>The WF operates normally after repeated dropping.</td>
</tr>
<tr>
<td><strong>Positive Not Negative</strong></td>
<td>“the WF is difficult to hold.”</td>
<td>The WF is not difficult to hold.</td>
<td>The WF is easy to hold</td>
</tr>
<tr>
<td><strong>Product Attribute</strong></td>
<td>“I need to attach a virus filter to the WF.”</td>
<td>A virus filter can be attached to the WF.</td>
<td>WF accommodates a virus filter</td>
</tr>
<tr>
<td><strong>Avoid “Must” &amp; “Should”</strong></td>
<td>“The water should taste good.”</td>
<td>The WF should deliver good tasting water</td>
<td>The WF delivers good tasting water.</td>
</tr>
</tbody>
</table>
# Customer Needs (e.g., Page Turner)

<table>
<thead>
<tr>
<th>Question</th>
<th>Customer Statement</th>
<th>Interpreted Need</th>
<th>Importance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Typical uses</td>
<td>• Independent use by student</td>
<td>• Operable by person with disabilities</td>
<td>(must) 4</td>
</tr>
<tr>
<td>Likes</td>
<td>• Portable, Mobile</td>
<td>• Portable</td>
<td>(good) 3</td>
</tr>
<tr>
<td></td>
<td>• Auditory sound provided when page is turned</td>
<td>• Signals when performing desired actions</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Adjustable stand for different book sizes</td>
<td>• Adjusts to different book sizes</td>
<td></td>
</tr>
<tr>
<td>Dislikes</td>
<td>• Used so much that we wore it out</td>
<td>• Lightweight</td>
<td>(good) 3</td>
</tr>
<tr>
<td></td>
<td>• Heavy</td>
<td>• Repairable by staff</td>
<td>(good) 3</td>
</tr>
<tr>
<td></td>
<td>• Need consistent page turning</td>
<td>• Easily replaceable parts</td>
<td>(must) 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Predictable page turning</td>
<td>(must) 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Low failure rate</td>
<td>(should) 2</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Long mean time between failures</td>
<td></td>
</tr>
<tr>
<td>Suggested Improvements</td>
<td>• Built in delay for multiple button pushes</td>
<td>• Turns variety of page types</td>
<td>(should) 2</td>
</tr>
<tr>
<td></td>
<td>• Be able to turn newspaper pages</td>
<td>• Accounts for accidental, repeat button pushes</td>
<td>(good) 3</td>
</tr>
<tr>
<td></td>
<td>• Be able to turn scrapbook pages</td>
<td>• Operable by multiple persons</td>
<td>(must) 4</td>
</tr>
<tr>
<td></td>
<td>• Multiple students can share</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Linking Customer Needs to Specifications

Engineering Requirements and Specifications Translate Voice of the Customer to Technology

TABLET DEVICE COMPARISON

<table>
<thead>
<tr>
<th>Model</th>
<th>Display size (resolution)</th>
<th>Weight</th>
<th>OS</th>
<th>Processor</th>
<th>Memory</th>
<th>Connectivity</th>
<th>Multimedia</th>
<th>Camera</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Samsung Galaxy Tab 7</td>
<td>7-inch diagonal (1024 x 600 pixels)</td>
<td>680g</td>
<td>Android 3.0</td>
<td>1GHz</td>
<td>1GB</td>
<td>Bluetooth 2.1, Wi-Fi, 3G</td>
<td>3.2mm audio jack, built-in speaker &amp; mic, 1080p video, video calling</td>
<td>2MP front, 5MP rear</td>
<td>$520 to $550</td>
</tr>
<tr>
<td>Motorola XOOM</td>
<td>10.1-inch diagonal (1280 x 800 pixels)</td>
<td>750g</td>
<td>Android 3.0</td>
<td>1.0GHz</td>
<td>1GB</td>
<td>Bluetooth 2.1, Wi-Fi, 3G</td>
<td>3.2mm audio jack, built-in speaker &amp; mic, 1080p HD video, video calling</td>
<td>2MP front, 5MP rear</td>
<td>$699 to $799</td>
</tr>
<tr>
<td>BlackBerry Playbook</td>
<td>7-inch diagonal (1024 x 600 pixels)</td>
<td>400g</td>
<td>iOS 4.3</td>
<td>1.0GHz</td>
<td>1GB</td>
<td>Bluetooth 2.1, Wi-Fi, 3G</td>
<td>3.2mm audio jack, built-in speaker &amp; mic, 1080p HD video, video calling</td>
<td>2MP front, 5MP rear</td>
<td>$269 to $399</td>
</tr>
<tr>
<td>Apple iPad 2</td>
<td>9.7-inch diagonal (1024 x 768 pixels)</td>
<td>624g</td>
<td>Android 3.0</td>
<td>1.0GHz</td>
<td>1GB</td>
<td>Bluetooth 2.1, Wi-Fi, 3G</td>
<td>3.2mm audio jack, built-in speaker &amp; mic, 1080p HD video, video calling</td>
<td>2MP front, 5MP rear</td>
<td>Not announced</td>
</tr>
</tbody>
</table>

Worldwide Media Tablet Sales and Tablet OS market share

<table>
<thead>
<tr>
<th>Year</th>
<th>iPad</th>
<th>Android</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>19.8</td>
<td>31.8</td>
<td>39.6</td>
<td>91.2</td>
</tr>
<tr>
<td>2011</td>
<td>19.7</td>
<td>35.4</td>
<td>44.9</td>
<td>99.0</td>
</tr>
<tr>
<td>2012</td>
<td>18.4</td>
<td>33.8</td>
<td>47.8</td>
<td>99.0</td>
</tr>
<tr>
<td>2013</td>
<td>19.2</td>
<td>33.7</td>
<td>47.1</td>
<td>99.0</td>
</tr>
</tbody>
</table>

CREATING THE NEXT®

26
Quality Function Deployment (QFD)

QFD is a design planning tool:
- for translating customer needs into appropriate product development requirements
- that identifies the significant item on which to focus time, product improvement efforts and other resources

QFD enables:
- the identification of important issues and items
- the identification of trade-offs and synergies
Effect of QFD on Performance

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

January 1977 Pre QFD
April 1984 Post QFD (39% of pre QFD costs)

- Preproduction costs
- Startup costs

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

- Changes = Money
- Earlier Changes = Less Money Spent

House of Quality (HOQ)

- Design tool for coordinating design efforts towards goods customers WANT
- House of quality (HOQ) is part of QFD
- Focus on quality and customer needs across the design process and across corporate boundaries
- Guide design priorities based on customer needs and competitive benchmarking
- Over 70% of US companies use QFD (Ford, Xerox, Toyota …)
House of Quality (HOQ)

HOQ Translates Needs to Specifications

Customer desires (*qualitative*)

Not tied to product/concept

Example: “portable”

- **Customer Needs**
- **HOQ**
- **Engineering Requirements and Specifications**

Product performance (*quantitative*)

~Not tied to product solutions

**TESTABLE NOT A TEST**

Specification is a:

- Metric with **Target Value** & units
  - mass $< 0.1 \text{ kg}$
  - volume $< 250 \text{ cm}^3$

Revised throughout design
House of Quality (HOQ) components

- Customer needs
- Engineering metrics/requirements
  - Targets
  - Direction of improvement
  - Conflict/synergies
- Relationship matrix
- Correlation matrix
- Alternative products
Customer needs:
• These are the ‘whats’
• Assigned numerical importance 1-10

Engineering metrics/requirements:
• These are the ‘hows’
• Determine most important ones using RM
• Determine synergies/conflicts with CM

Relationship matrix (RM):
• Maps relationship between hows and whats
• Quantitative relationship levels - 1, 3 and 9

Correlation matrix (CM):
• Maps correlation between engineering requirements
• Strong positive, positive, negative, strong negative

House of Quality (HOQ) components
# Relationship Matrix in HOQ

<table>
<thead>
<tr>
<th>Direction of Improvement</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
<th>OEOEOEOE OEOOE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering Requirements</td>
<td>grip force required of operator</td>
<td>total mass</td>
<td>carrying dimensions</td>
<td>auditory volume of signals</td>
<td>intensity of visual signals</td>
<td>error in aligning parts</td>
<td># specialty components</td>
<td># tools needed to repair</td>
<td>granularity of page turning control</td>
<td>error rate in page turning</td>
<td>rate of wear of components</td>
<td>adjustable range of dimensions</td>
</tr>
<tr>
<td>Customer Requirements (Explicit and Implicit)</td>
<td>tolerable non-interrupted motions</td>
<td>lightweight</td>
<td>repairable by staff</td>
<td>easily replaceable parts</td>
<td>predictable page turning</td>
<td>low failure rate</td>
<td>safely handles variety of reading materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>operable by person with disabilities</td>
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<tr>
<td>Portable/Mobile</td>
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<tr>
<td>Signals when performing desired actions</td>
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<tr>
<td>lightweight</td>
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</tbody>
</table>

Note: The symbols represent relationships: ▲ for strong positive, ▼ for strong negative, ◇ for weak positive, ○ for weak negative, ◆ for no relationship.
### Correlation Matrix in HOQ

#### Column #
- Tolerance of user-initiated motions
- Grip force required of operator
- Total mass
- Carrying dimensions
- Auditory volume of signals
- Match signals with user generated action
- Intensity of visual signals
- Error in aligning parts
- # Specialty components
- # Tools needed to repair
- Granularity of page turning control
- Error rate in page turning
- Rate of wear of components
- Adjustable range of dimensions
- Force on the page

<table>
<thead>
<tr>
<th>Force on the page</th>
<th>Error rate in page turning</th>
<th>Rate of wear of components</th>
<th>Adjustable range of dimensions</th>
<th>Granularity of page turning control</th>
<th>Error in aligning parts</th>
<th>Number of assembly and disassembly orientations</th>
<th>Intensity of visual signals</th>
<th>Match signals with user generated action</th>
<th>Auditory volume of signals</th>
<th>Carrying dimensions</th>
<th>Total mass</th>
<th>Grip force required of operator</th>
<th>Tolerance of user-initiated motions</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>-</td>
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</tr>
</tbody>
</table>
Target Values for Engineering Requirements

Determine how specific values for engineering requirements influence satisfaction of customer needs

- Scientific studies
- Survey tests
- Focus groups
- Refer to standards organizations (NIOSH, OSHA, NIST, ASTM, etc)

Figure 13.9 Coffee quality chart. (Adapted from American Coffee Brewing Institute and reproduced by courtesy of Van Nostrand Reinhold.)
HOQ Example (e.g., Coffee)

**What**
- Hot
- Taste
- Smell
- Stimulating
- Aesthetics
- Color
- Cost
- Grounds
- Not poisonous (assumed)

**How**
- Serving temperature (Hot)
- Taste jury (Taste)
- Smell jury (Smell)
- Measure caffeine level (Stimulating)
- Jury (Aesthetics)
- Color standard (Color)
- Price (Cost)
- Filter & weigh (Grounds)
- Lethal Dose LD 50 (Not poisonous)
Matrix Weights

- Strong, $\Theta = 9$
- Medium, $\Theta = 3$
- Weak, $\Delta = 1$

- The 181 from column 1 comes from:
$$ (8)(9) + (6)(3) + (9)(9) + (10)(1) = 181 $$

- The sum of the Absolute Importance row is:
$$ 181 + 132 + 54 + 99 + 18 + 108 + 90 = 682 $$

- The 0.27 in the first column of the Relative Importance row comes from:
$$ \frac{181}{682} = 0.2654 \approx 0.27 $$
Analyzing and Diagnosing the HOQ

Look for:

- Blank rows – unaddressed customer need
- Blank columns – unimportant engineering requirement
- Communication opportunities
- Sales Points – competitors strengths/features
- Resolve or prioritize negative correlations
- Final correct targets
- Determining planned quality
- What design requirements to be deployed to Phase II (Parts Deployment)
4 Phases of QFD

Product planning
• What will it do?
• What will it look like?

Part deployment
• How will it do it?

Process planning
• How will we make it?

Production planning
• Develop details in how to make it.
4 Phases of QFD (e.g., Car Door)

Product planning
- Close door easily
- Close fit

Part deployment
- Weather strip
- Latch

Process planning (W. Strip)
- Extrude

Production planning
- Temperature
- Pressure
- Speed
Summary – QFD/HOQ

Customer requirements
• Rank based on customer priority

Engineering requirements
• Must be measurable (e.g., engineering units), have improvement direction and a target value
• Rate relationship to customer requirements
• Relate tradeoffs with other engineering reqs.
• Determine most important ones using calculation

Describing this figure in text
• Describe chart’s contents, not what the chart is itself!
• What is important for each set of data?
• Use numerical information from figure

See Ch. 2 in book for detail, templates online
Specifications: metrics lead to solutions
Linking Customer Needs to Specifications

Engineering Requirements and Specifications Translate Voice of the Customer to Technology

---

### TABLET DEVICE COMPARISON

<table>
<thead>
<tr>
<th>Feature</th>
<th>Samsung Galaxy Tab 2 (10.1-inch diagonal)</th>
<th>Samsung Galaxy Tab 2 (10.1-inch diagonal)</th>
<th>BlackBerry PlayBook (7-inch diagonal)</th>
<th>Apple iPad 2 (9.7-inch diagonal)</th>
<th>Apple iPad 2 (9.7-inch diagonal)</th>
<th>Samsung Galaxy Tab 2 (10.1-inch diagonal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Display Size (resolution)</td>
<td>10.1-inch diagonal (1280 x 800 pixels)</td>
<td>10.1-inch diagonal (1280 x 800 pixels)</td>
<td>7-inch diagonal (1024 x 600 pixels)</td>
<td>9.7-inch diagonal (1024 x 768 pixels)</td>
<td>9.7-inch diagonal (1024 x 768 pixels)</td>
<td>10.1-inch diagonal (1280 x 800 pixels)</td>
</tr>
<tr>
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<td>BlackBerry OS 7.1</td>
<td>iOS 4.3</td>
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<td>Multimedia</td>
<td>3.5mm audio jack, built-in speaker &amp; mic, 1080p video, video calling</td>
<td>3.5mm audio jack, built-in speaker &amp; mic, 1080p video, video calling</td>
<td>3.5mm audio jack, built-in speaker &amp; mic, 1080p video, video calling</td>
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<td>1.3MP front, 1.3MP rear</td>
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<td>$499 to $529</td>
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**Worldwide Media Tablet Sales to End-Users (in millions of units, forecast)**

<table>
<thead>
<tr>
<th>Year</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>2014</th>
<th>2015</th>
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<td>Q1</td>
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<td>94.5</td>
<td>93.5</td>
<td>92.5</td>
<td>91.5</td>
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<tr>
<td>Q2</td>
<td>94.5</td>
<td>93.5</td>
<td>92.5</td>
<td>91.5</td>
<td>90.5</td>
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</tr>
<tr>
<td>Q3</td>
<td>93.5</td>
<td>92.5</td>
<td>91.5</td>
<td>90.5</td>
<td>89.5</td>
<td>88.5</td>
</tr>
<tr>
<td>Q4</td>
<td>92.5</td>
<td>91.5</td>
<td>90.5</td>
<td>89.5</td>
<td>88.5</td>
<td>87.5</td>
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</table>

**Tablet OS market share**

<table>
<thead>
<tr>
<th>Year</th>
<th>Q3 2010</th>
<th>Q4 2010</th>
<th>Q1 2011</th>
</tr>
</thead>
<tbody>
<tr>
<td>iOS</td>
<td>95.5%</td>
<td>94.5%</td>
<td>93.5%</td>
</tr>
<tr>
<td>Android</td>
<td>5.5%</td>
<td>5.5%</td>
<td>6.5%</td>
</tr>
<tr>
<td>Others</td>
<td>3%</td>
<td>2%</td>
<td>1%</td>
</tr>
</tbody>
</table>

---

**Creating the Next**

43
Video – Airpods 2
Specifications: Performance/engineering requirements that product must meet or exceed.

Specifications sheet:
• Indicates changes to engineering requirements
• Indicates importance of the engineering requirement (demand or wish)
• Provides a quantifiable requirement (unit and value, or standard)
• Assigns responsibility
• Provides source justification (standard, calculation, report, survey, etc.)

Connection to HOQ / QFD
## Specification List

**D = Demand  W = Wish**

<table>
<thead>
<tr>
<th>Changes</th>
<th>D/W</th>
<th>Specification for: Requirements</th>
<th>Issued:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Replaces issue of</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Resp.</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Page 1</td>
</tr>
</tbody>
</table>

---

**Georgia Tech**

**CREATING THE NEXT**

46
Specification List Checklist

Geometry

- Size, height, breadth, length, diameter, space requirement, number, arrangement, connection extension

Kinematics

- Type of motion, direction of motion, velocity, acceleration

Forces

- Direction of force, magnitude of force, frequency, weight, load, deformation, stiffness, elasticity, stability, resonance

Energy

- Output, efficiency, loss, friction, ventilation, state, pressure, temperature, heating, cooling, supply, storage, capacity, conversion
Specification List Checklist

Material
- Physical and chemical properties of the initial and final product, auxiliary material, prescribed materials (food regulations, etc.)

Signals
- Inputs and outputs, form, display, control equipment

Safety
- Direct safety principles, protective systems, operational, operator and environmental safety

Ergonomics
- Person-machine relationship, type of operation, cleanliness of layout, lighting, aesthetics

Production
- Factory limitations, maximum possible dimensions, preferred production methods, means of production, achievable quality and tolerance
Specification List Checklist

Quality control
• Possibilities of testing and measuring, application of special regulations and standards

Assembly
• Special regulations, installation, siting, foundations

Transport
• Limitations due to lifting gear, clearance, means of transport (height and weight), nature and conditions of dispatch

Operation
• Quietness, wear, special uses, marketing area, destination (for example, sulphurous atmosphere, tropical conditions)
Specification List Checklist

Maintenance
  • Servicing intervals (if any), inspection, exchange and repair, painting, cleaning

Recycling
  • Reuse, reprocessing, waste disposal, storage

Costs
  • Maximum permissible manufacturing costs, cost of tooling, investment and depreciation

Schedules
  • End date of development, project planning and control, delivery date
## Coffee Example

Entries in Houses of Quality From QFD Deployment are Sources Of Specifications

<table>
<thead>
<tr>
<th>House Of Quality #1</th>
<th>House Of Quality #2</th>
<th>House Of Quality #3</th>
<th>House Of Quality #4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What</strong></td>
<td><strong>How / What (#2)</strong></td>
<td><strong>How / What (#3)</strong></td>
<td><strong>How / What (#4)</strong></td>
</tr>
<tr>
<td>Cust. Req.</td>
<td></td>
<td></td>
<td>How</td>
</tr>
<tr>
<td>Hot</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smells Good</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tastes Good</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cheap</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Good Color</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Poisonous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No Grounds</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Characteristic</strong></td>
<td><strong>Feature</strong></td>
<td><strong>Process</strong></td>
<td><strong>Production</strong></td>
</tr>
<tr>
<td>Serving Temp.</td>
<td>Water Temp.</td>
<td>Water Speed</td>
<td>Thermometer</td>
</tr>
<tr>
<td>Smell Jury</td>
<td>Bean's Origin</td>
<td>Heater Output</td>
<td>Flow Control</td>
</tr>
<tr>
<td>Taste Jury</td>
<td>Water Quality</td>
<td>Brew Time</td>
<td>Timer</td>
</tr>
<tr>
<td>Price</td>
<td>Weight/Serving</td>
<td>Brew Temp.</td>
<td>Cleaning Plan</td>
</tr>
<tr>
<td>Color Std.</td>
<td>Finess Of Ground.</td>
<td>Grind Setting</td>
<td>Disposal Plan</td>
</tr>
<tr>
<td>Analysis</td>
<td>Age Of Coffee</td>
<td></td>
<td>(Raw, Brewed)</td>
</tr>
<tr>
<td>Filter/Weigh</td>
<td>(Raw, Brewed)</td>
<td></td>
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# Coffee Specifications #1

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<tr>
<th>Changes</th>
<th>D/W</th>
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<th>Resp</th>
<th>Source</th>
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<tr>
<td></td>
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<td>Cup Of Coffee</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Hot</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Material</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>Good Color</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>Non-Poisonous</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>No Grounds</td>
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<td></td>
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<tr>
<td></td>
<td></td>
<td>Safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Poisonous</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
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<td>Signals</td>
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<td>Good Color</td>
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<td></td>
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<td>Smells Good</td>
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<tr>
<td></td>
<td></td>
<td>Tastes Good</td>
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<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Costs</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Cheap</td>
<td></td>
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</tr>
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<td></td>
<td>Good Color</td>
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<td></td>
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<td>Smells Good</td>
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<td></td>
<td>Tastes Good</td>
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<tr>
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<td></td>
<td>Replaces Issue Of</td>
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1st HoQ WHATs from class
Next Level Of Detail In Specs...

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<thead>
<tr>
<th>House Of Quality #1</th>
<th>House Of Quality #1</th>
<th>House Of Quality #2</th>
<th>House Of Quality #3</th>
<th>House Of Quality #4</th>
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</thead>
<tbody>
<tr>
<td>Cust. Req.</td>
<td>Characteristic</td>
<td>Feature</td>
<td>Process</td>
<td>Production</td>
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<tr>
<td>Hot</td>
<td>Serving Temp.</td>
<td>Water Temp.</td>
<td>Water Speed</td>
<td>Thermometer</td>
</tr>
<tr>
<td>Smells Good</td>
<td>Smell Jury</td>
<td>Bean’s Origin</td>
<td>Heater Output</td>
<td>Flow Control</td>
</tr>
<tr>
<td>Tastes Good</td>
<td>Taste Jury</td>
<td>Water Quality</td>
<td>Brew Time</td>
<td>Timer</td>
</tr>
<tr>
<td>Cheap</td>
<td>Price</td>
<td>Weight/Serving</td>
<td>Brew Temp.</td>
<td>Cleaning Plan</td>
</tr>
<tr>
<td>Good Color</td>
<td>Color Std.</td>
<td>Fineness Of Ground.</td>
<td>Grind Setting</td>
<td>Disposal Plan</td>
</tr>
<tr>
<td>Non-Poisonous</td>
<td>Analysis</td>
<td>Age Of Coffee</td>
<td>Water Source</td>
<td>(Raw, Brewed)</td>
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<tr>
<td>No Grounds</td>
<td>Filter/Weigh</td>
<td>(Raw, Brewed)</td>
<td>Filter Quality</td>
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<td></td>
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<td>Time To Serving</td>
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<td>(Renew Filter, Grounds)</td>
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## Coffee Specifications #2: “Hows?”

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<tr>
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<td>for: <strong>Cup Of Coffee</strong></td>
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<tr>
<td></td>
<td></td>
<td><strong>Energy:</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Serving Temperature</td>
<td>1st HoQ from class</td>
</tr>
<tr>
<td>10/3/95</td>
<td></td>
<td><strong>Material:</strong></td>
<td></td>
</tr>
<tr>
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<td>10/3/95</td>
<td>Color Std</td>
<td>NIST STD</td>
</tr>
<tr>
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<td>10/3/95</td>
<td>Non-Poisonous</td>
<td>FDA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brewed Coffee Should Yield Minimum Coffee Grounds When Filtered</td>
<td>1st HoQ from class</td>
</tr>
<tr>
<td>10/3/95</td>
<td></td>
<td><strong>Safety:</strong></td>
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</tr>
<tr>
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<td>10/3/95</td>
<td>Non-Poisonous</td>
<td>FDA</td>
</tr>
<tr>
<td>10/3/95</td>
<td></td>
<td><strong>Signals:</strong></td>
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<td>10/3/95</td>
<td>Color Std</td>
<td>NIST STD</td>
</tr>
<tr>
<td></td>
<td>10/3/95</td>
<td>Smells Jury</td>
<td>1st HoQ from class</td>
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<td>10/3/95</td>
<td>Taste Jury</td>
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<td><strong>Costs:</strong></td>
<td>1st HoQ from class</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Minimize Price</td>
<td></td>
</tr>
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<td></td>
<td>10/3/95</td>
<td><strong>Quality Control:</strong></td>
<td>1st HoQ from class</td>
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<td></td>
<td>Color Std</td>
<td>NIST STD</td>
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<td>10/3/95</td>
<td>Smells Jury</td>
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<tr>
<td></td>
<td>10/3/95</td>
<td>Taste Jury</td>
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Replaces issue of Coffee Specifications #2: “Hows?”
## Coffee Specifications #3: “How Much?”

<table>
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<td>Cup Of Coffee</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Energy:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Serving Temperature, 140°F</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Material:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Color Std, NIST #?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Poisonous, &lt; X₁, X₂, ...mg/l</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Brewed Coffee Should Yield &lt; Y mg/l Coffee Grounds When Filtered</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/4/95</td>
<td></td>
<td>Safety:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Non-Poisonous, &lt; X₁, X₂, ...mg/l</td>
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<td></td>
</tr>
<tr>
<td>10/4/95</td>
<td></td>
<td>Signals:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Color Std, NIST #?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Smells Jury, 95% Consensus</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Taste Jury, 95% Consensus</td>
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<td>10/4/95</td>
<td></td>
<td>Costs:</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Minimize Price</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10/4/95</td>
<td></td>
<td>Quality Control:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Color Std, NIST #?</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Smells Jury, 95% Consensus</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Taste Jury, 95% Consensus</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Replaces Issue Of</td>
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</tr>
</tbody>
</table>

1st Hoq From Class
NIST STD
FDA
1st Hoq From Class
FDA
NIST STD
1st Hoq From Class
*
## Continue with Next Level of Detail in Specs

<table>
<thead>
<tr>
<th>House Of Quality #1</th>
<th>House Of Quality #1</th>
<th>House Of Quality #2</th>
<th>House Of Quality #3</th>
<th>House Of Quality #4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>What</strong></td>
<td><strong>How / What (#2)</strong></td>
<td><strong>How / What (#3)</strong></td>
<td><strong>How / What (#4)</strong></td>
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</tr>
<tr>
<td>Hot</td>
<td>Characteristic</td>
<td>Feature</td>
<td>Process</td>
<td>Production</td>
</tr>
<tr>
<td>Smells Good</td>
<td>Serving Temp.</td>
<td>Water Temp.</td>
<td>Water Speed</td>
<td>Thermometer</td>
</tr>
<tr>
<td>Tastes Good</td>
<td>Smell Jury</td>
<td>Bean’s Origin</td>
<td>Heater Output</td>
<td>Flow Control</td>
</tr>
<tr>
<td>Cheap</td>
<td>Taste Jury</td>
<td>Water Quality</td>
<td>Brew Time</td>
<td>Timer</td>
</tr>
<tr>
<td>Good Color</td>
<td>Price</td>
<td>Weight/Serving</td>
<td>Brew Temp.</td>
<td>Cleaning Plan</td>
</tr>
<tr>
<td>Non-Poisonous</td>
<td>Color Std.</td>
<td>Fineness Of Ground.</td>
<td>Grind Setting</td>
<td>Disposal Plan</td>
</tr>
<tr>
<td>No Grounds</td>
<td>Analysis</td>
<td>Age Of Coffee</td>
<td>Water Source</td>
<td>(Raw, Brewed)</td>
</tr>
<tr>
<td></td>
<td>Filter/Weigh</td>
<td>(Raw, Brewed)</td>
<td>Filter Quality</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>TIME TO SERVING</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>REINITIALIZE</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>(RENEW FILTER,</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GROUNDS)</td>
<td></td>
</tr>
</tbody>
</table>

**TIME TO SERVING**: REINITIALIZE (RENEW FILTER, GROUNDS)

*Continue with Next Level of Detail in Specs*
Summary – Specification Sheet

Elements
• List engineering requirements from HOQ
• Add other specifications that are useful
• Make sure specifications can be measured
• Do not specify specifications dependent on design decisions, design choices come later!

Describing this figure in text
• Describe the contents, not the tool itself!
• What are critical specifications?
• Use numerical information from figure.

See Ch. 4 in book for detail, templates online
Learning Objectives

- Identify types of customers
- Identify and interpret customer needs
- Define engineering requirements
- Translate customer needs to engineering requirements using a house of quality (HOQ)
- Use a HOQ to show relationships among customer needs and engineering requirements
- Create a specifications list from engineering requirements and customer needs