Methods for Managing Customer Needs

Goal of this lecture

- Introduce you to three tools
  - HoQ
  - FMEA
  - Requirements flowdown
- Understand the uses/problems of each
- Assignment
  - Need to perform FMEA, HoQ and requirements flowdown on your product
  - Need to identify with these tools the key risks
Wide variety of tools that

- Highlight problems
- Highlight tradeoffs
- Used to facilitate discussion
- Create “to-do” lists or responsibility lists
- To organize and systematically manage critical issues

Three tools

- House of Quality (HoQ)
- Failure modes and effects analysis (FMEA)
- Requirements flowdown
HOQ

Benefits
• Captures relationships
• Traceable
• Competitive information included

Problems
• Time consuming
• EQFD almost never done
• Difficult to see linkages and system interfaces
• Mixing problems
  • nominal
  • variation

Failure Modes and Effects Analysis

• Tool to
  – identify failure
  – assess failure
  – identify actions to mitigate risk of failure
    • redesign
    • special control
• It is a living document that should be
  – started in the beginning of the design
  – followed through to production
## FMEA

<table>
<thead>
<tr>
<th>Failure</th>
<th>Cause</th>
<th>Detection</th>
<th>Action</th>
<th>Action Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deposit Ink</td>
<td>Too little</td>
<td>Clogged Heads</td>
<td>None - instructions to user to regularly clean heads</td>
<td>More Robust Design</td>
</tr>
<tr>
<td></td>
<td>Low Ink Levels</td>
<td>Ink Level Light</td>
<td>Safety</td>
<td>Improved</td>
</tr>
<tr>
<td></td>
<td>Can't read</td>
<td>Failure in Print head</td>
<td>Ink head design team</td>
<td>8</td>
</tr>
</tbody>
</table>

### Text in FMEA

- List all functions
- Use a cross functional team to identify
  - potential failure mode for each function
  - effect of that failure mode
  - cause of failure mode
  - current design controls (redundancy, error checking, testing)
### Severity

10 - Hazardous Effect  
9 - Serious Effect  
8 - Extreme Effect  
7 - Major Effect  
6 - Significant Effect  
5 - Moderate Effect  
4 - Minor Effect  
3 - Slight Effect  
2 - Very Slight Effect  
1 - No Effect

### Occurrence

10 - Almost Certain (> 1 in 2)  
9 - Very high (1 in 3)  
8 - High (1 in 8)  
7 - Moderately High (1 in 20)  
6 - Medium (1 in 80)  
5 - Low (1 in 400)  
4 - Slight (1 in 2,000)  
3 - Very Slight (1 in 15,000)  
2 - Remote (1 in 150,000)  
1 - Almost Never (<1 in 1,500,000)

### Detection

10 - Almost impossible - no known method to detect  
9 - Remote (unreliable)  
8 - Very slight  
7 - Slight  
6 - Low  
5 - Medium  
4 - Moderately high  
3 - High  
2 - Very High  
1 - Almost Certain

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**Example for Auto Industry:**

S6 - Customer experience discomfort. Vehicle Performance degraded but operable and safe. Partial loss of System function, but operable

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**Severity, Occurrence and Detection**

- **Numbers are**
  - product specific
  - product stage specific (i.e., early in design vs. production)

- **Meaning should be**
  - agreed on by the Cross functional team
  - consistently used
Risk Priority Number

- RPN = Severity * Occurrence * Detection
- Rank order according to RPN
- No physical meaning to RPN.
- Used to “bucket problems”
- Don’t spend a lot of time worrying about what a measure of “42” means

Meaning of RPN

- Severity High, Occurrence High, Detection Low (i.e., can be detected)
  - Although the problem is of high risk it can easily be detected
- Severity Medium, Occurrence High, Detection High (i.e., can not be detected)
  - Large chance of a problem but can not be detected so it needs extra action
Debate on RPN

- Two failure modes may have the same RPN
  - S - 10, O - 1, D - 2 (RPN = 20)
  - S - 1, O - 5, D - 4
- Which one deserves more attention
  - Typically, anything that has a failure mode of 10 is automatically addressed

Actions

- This is the important part of the FMEA
- Change design to reduce
  - Severity (redundancy)
  - Occurrence (change in design, or processes)
  - Detection (improve ability to identify the problem before it becomes critical)
- Assign a person or a team to the problem
- Follow up and assess the action with a new RPN number
FMEAA Levels

- **FMEA - 1 (Concept)**
  - Failures in the concept (inability to achieve performance)
  - Detection
    - ability to find the failures (i.e., use of historical data, early models, etc.)

- **FMEA - 2 (Design)**
  - Failures in current design (performance)
  - Detection
    - highlighting failures during the detail design phase (i.e., crash simulations)

- **FMEA - 3 (Process)**
  - Failures in production process
  - Detection
    - finding the errors in the production line (i.e., SPC, inspection)

Relationships

<table>
<thead>
<tr>
<th>Concept</th>
<th>Effect</th>
<th>Cause</th>
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<tbody>
<tr>
<td>Low ink deposition</td>
<td>Faint printing</td>
<td>Clogged ink jets</td>
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</table>

<table>
<thead>
<tr>
<th>Design</th>
<th>Effect</th>
<th>Cause</th>
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<tbody>
<tr>
<td>Clogged Ink Jet</td>
<td>Faint printing</td>
<td>Incorrect Hole size</td>
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<table>
<thead>
<tr>
<th>Process</th>
<th>Effect</th>
<th>Cause</th>
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</thead>
<tbody>
<tr>
<td>Incorrect Hole size</td>
<td>Faint printing</td>
<td>Process out of control</td>
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</tbody>
</table>
**Uses**

- **Concept**
  - Identify where the *concept* can be changed to prevent failure
- **Design**
  - Identify where *design* can be optimized to reduce the chance of failure
- **Process**
  - Identify where the *process* can be optimized to reduce the chance of failure

### Failures Cause Detection

<table>
<thead>
<tr>
<th>Item</th>
<th>Potential Failure Mode</th>
<th>Effect</th>
<th>Severity</th>
<th>Cause</th>
<th>Occurrence</th>
<th>Design Control</th>
<th>Detection</th>
<th>RPN</th>
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**IPPD 2/17/00 HoQ and FMEA**
FMEA

Benefits
Systematic way to manage failures
Comprehensive
Prioritizes

Problems
Based on qualitative assessment
Unwieldy
Hard to trace through levels
Not always followed up

Requirements flowdown

- A product is made up of many possible sub-systems.
- Typically products designed by multiple teams
- Integrating these sub-systems requires
  - Systems engineers
  - Clear requirements for each sub-system
System Engineering

- Creates a set of specifications for each
- Entitled “requirements flowdown”
- Several types of flowdowns
  - Functional
  - Budget
  - Interface

Functional flowdown

- Performance of the system is a function of the parameters of two or more subsystems
- Print quality = f(speed of paper handling, skew of paper, wrinkling of the paper, image imprint quality)
- Need to understand system function and allocate the “variables” to the sub systems
**Budgets**

- There is often a limited commodity in a product
  - Temperature
  - Power
  - Variation
  - Volume
- Each sub-system gets allocated a budget that they must meet or exceed
- System engineer’s role is to allocate and reallocate

**Interfaces**

- To ensure the final product works, the interface standards must be set
- Holes, plugs, shapes, communication protocol
- These need to be set, managed, and adhered to.
Take your product

• Generate the start of a “concept failure”
  FMEA

Problems with all tools

• Done as a box-checking
• Done but not followed up
• Done but not maintained
• Done but with the wrong people
Goal of this lecture

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  - Need to perform FMEA, HoQ and requirements flowdown on your product
  - Need to identify with these tools the key risks

Next Thursday (no class tues)

- Case: Toyota Motor Corporation: Target Costing System,
- Reading
  - Cooper: Target Costing and Value Engineering.
  - Nagle The Strategy and Tactics of Pricing.
- What is target costing and how can it be used?
- How did Toyota use it?
- What type of products make target costing difficult?
- How does product architecture effect the ability to execute target costing?
- How is target costing done on a new product?