Concept Generation and Selection

EE4900 Senior Design
Prepared by: Rick Berkey
October 10, 2006
Outline

- Overview of Development Process
- Concept designs
- Concepts, brainstorming, and teaming
- The 10-step method
- Application on your projects
- Questions
- Additional references
Phases of a Development Process

- Identify Customer Needs
  - Who is/are your customer(s)?
  - What are their needs? What is most important?
  - Can these needs be translated into measurable criteria?

- Concept Definition
  - How many different ways can we achieve the customer requirements?
  - What is the best design concept with which to move forward?

- Planning and Specification
  - What are the performance/design specifications?
  - What are the design criteria (inputs) that achieve the customer requirements (outputs)? $Y=f(x)$

- Development
  - What are the detailed design criteria – values and tolerances?
  - How does manufacturing capability factor into design performance?
  - How can you improve the design for robustness and value?

- Validation
  - How well do prototypes meet customer requirements?
  - Does your design work over the range of expected conditions?

- Delivery and Support
  - How do you ensure consistency AFTER delivery?
  - What needs to be monitored and how often?
  - What happens when parts/processes/materials do not meet specs.?
Concept Designs

- **What?** A concept design is simply a ‘big-picture’ solution to your customer requirements.

- **When?** Explore concepts BEFORE locking in on a detailed design, but only AFTER you have determined your customer needs.

- **The goal?** A robust concept...more on this later.

Concept car designs:

Detailed design: features.pdf
Concepts, Brainstorming, and Teaming – A Balanced Approach

more options, more time up-front

Brainstorming

Planning

Teams

Concept Generation and Selection

Individuals

Structure

Execution

better at evaluation

drives purpose, decision, and documentation

no ‘bad’ ideas, out-of-the-box thinking

better at creativity

less flexibility, more costly to make changes

better at creativity

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Concept Generation and Selection in 10-steps

1. Determine customer requirements for your design
2. Define importance / weighting factors for these requirements
3. Decide how the team will convey concepts
4. Establish a strong base-case concept
5. Generate MANY concepts
6. Evaluate concepts using a Pugh matrix
7. Identify the best 2-3 new concepts
8. Look for hybrid solutions and identify a new base-case
9. Do a reality check - start over if needed
10. Select a robust concept and move forward
1. Determine customer requirements

- Requirements are functional product or service measures that directly relate to the customer’s true needs
- Determine through communication with your sponsor, input from their customers, etc.
- Could have more than one set of customers

**Example:** Design a transportation system to get to class

<table>
<thead>
<tr>
<th>4. Customer Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>low cost</td>
</tr>
<tr>
<td>reliable, year-round</td>
</tr>
<tr>
<td>flexible to class schedule</td>
</tr>
<tr>
<td>short commute time</td>
</tr>
<tr>
<td>comfortable</td>
</tr>
<tr>
<td>safe</td>
</tr>
<tr>
<td>marketing - fashionable, status symbol</td>
</tr>
<tr>
<td>can socialize on the way</td>
</tr>
<tr>
<td>environmentally friendly</td>
</tr>
</tbody>
</table>
2. Define importance/weighting factors for the requirements

- Not everything is equally important
- Looking at the needs in total, reducing risk of over/under designing
- Suggest a 1-3-5 scale for low-medium-high importance, respectively

**Example:** Design a transportation system to get to class

<table>
<thead>
<tr>
<th>Customer Requirements</th>
<th>5. Importance Weighting Factor (1-3-5 scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>low cost</td>
<td>5</td>
</tr>
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<td>reliable, year-round</td>
<td>5</td>
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<tr>
<td>flexible to class schedule</td>
<td>3</td>
</tr>
<tr>
<td>short commute time</td>
<td>1</td>
</tr>
<tr>
<td>comfortable</td>
<td>3</td>
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</tr>
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</table>
3. Decide how to convey concepts

- A standard way will drive an objective means of evaluation

- The nature of the design task will help determine a natural way to display

- Examples: Sketches, schematics, process flow maps, storyboards, Gantt charts

Example: Design a transportation system to get to class

Example: Design the best route to class
4. Establish a strong base-case concept

- The best initial design the team and/or sponsor have thought of
- The leading competitor’s approach
- The current design (if tasked with a redesign project) but...
- Needs to be strong – serves to ‘raise the bar’

**Example:** Design a transportation system to get to class

Base-case = walking
5. Generate MANY concepts

- You know your customer requirements, how to display your concepts, and the target to beat so…

- Get creative – allow time and place for individual creativity

- Quantity matters – inviting a ‘storm’ vs. a ‘drizzle’, defer all judgment at this stage

**Example:** Design a transportation system to get to class
6. Evaluate your concepts using a Pugh matrix

- **Pugh matrix** – a tool to facilitate the concept evaluation and selection process
- The base-case gets a score of ‘5’ for each of the customer requirements
- New concepts are scored relative to the base-case with a 1-5-9 approach:
  - Much worse than the base-case, score a ‘1’
  - Roughly equal to the base-case, score a ‘5’
  - Much better than the base-case, score a ‘9’
- Work across the matrix for each customer requirement

**Important:**
- **Dialog, listening, communication** – understand team differences
- **Consensus** - do not average individual scores or matrix will fail to yield useful info.
- **Directional tool** - only much better or worse matters
The completed Pugh matrix for our transportation system example

<table>
<thead>
<tr>
<th>Concept Selection Matrix</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Date: 10/10/06</td>
</tr>
<tr>
<td>2. Objective:</td>
</tr>
<tr>
<td>Design a transportation system to get to class</td>
</tr>
<tr>
<td>3. Target Customer:</td>
</tr>
<tr>
<td>Average MTU student</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th>4. Customer Requirements</th>
<th>5. Importance Weighing Factor (1-5 scale)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low cost</td>
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<td>5</td>
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<td>3</td>
</tr>
<tr>
<td>Environmentally friendly</td>
<td>6</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Totals</th>
<th>Walk</th>
<th>Drive</th>
<th>Bus</th>
<th>Snowmobile</th>
<th>Take the bus</th>
<th>Telecommute</th>
<th>Fly out of CMX</th>
<th>Subway Transporter</th>
</tr>
</thead>
<tbody>
<tr>
<td>45</td>
<td>53</td>
<td>45</td>
<td>33</td>
<td>41</td>
<td>57</td>
<td>41</td>
<td>45</td>
<td>0</td>
</tr>
</tbody>
</table>

| 5. Weighted Totals                      | 156  | 155   | 131 | 87         | 151          | 207         | 111            | 131               | 0                 |

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7. Identify the best 2-3 concepts

- Excluding the base-case, look at the highest weighted totals
- Proceed to step 8.
8. Look for hybrid concepts

- A modular approach: mixing and matching the best parts of the strongest concepts
- Encourages further idea generation – ‘what if we…’
9. Do a reality check

- Is your new base case ridiculous?
- Missing customer requirements?
- Unnecessary requirements?
- Weak initial base case?
- Team dynamics, effort?

"If ya don't know whur ta start, go back to da beginnin'." - Great Uncle Alfons, in 'Escanaba in Da Moonlight'

Is telecommuting really a viable solution for you to get to class?
10. Select a robust concept and move forward

- Has potential to **delight** the customer, not just satisfy
- Employs a **systems** approach
- Not easily copied by **competitors**
- Review with your **customer** – get feedback

*Team is now migrating from creativity & brainstorming towards action & decision*
Application on your projects

In your project teams, use the remaining class time to begin applying the 10-step process on your project. Some considerations:

- Are your customer needs adequately defined and translated into measurable criteria?
- How do you plan to get the importance weightings?
- (3) basic approaches due this week - is one of these a natural base-case?
- How will you encourage and maximize individual creativity in your teams?
- Materials/resources/logistics for brainstorming – space, sticky notes, whiteboards, flip charts, bar napkins?
- When do you need to present a proposed design concept to your sponsor?
Questions?
Additional references

TRIZ (pronounced ‘Trees’): Russian for Theory of Inventive Problem Solving

http://www.triz-journal.com/

Six Sigma Methodologies: can search here for tips on brainstorming, applications of Pugh matrix, etc.

http://www.isixsigma.com/