CSCE482: Senior Capstone Design
Today…

- “The Five Dysfunctions of a Team: A Leadership Fable”
- Reexamine the nine step design process
  - Some tools for your toolbox in thinking about design problems.
  - In particular we care about the first few steps right now.
**Nine Step Model of Design Process**

1. Recognizing the need
2. Defining the problem
3. Planning the project
4. Gathering information
5. Conceptualizing alternatives
6. Evaluating the alternatives
7. Selecting the preferred alternative
8. Communicating the design
9. Implementing the preferred design
Cost of Making Changes During Different Phases of the Design Life Cycle

- preliminary design
- detailed design
- production
- consumption

(cost of change, $)
Summary of the methodology

Identify the Need

Goal Statement

Objectives

Constraints

Design Criteria
Step 1: Identify the Need

Sandra: “Jane, we need you to design a stronger bumper for our new passenger car.”

Jane: “Why do we need a stronger bumper?”

Sandra: “Well, our current bumper gets easily damaged in low-speed collisions, such as those that occur in parking lots.”

Jane: “Well, a stronger bumper may be the way to go, but there may be better approaches. For example, what about a more flexible bumper that absorbs the impact but then returns to its original shape?”

Sandra: “I never thought of that. I guess I was jumping to conclusions. Let’s restate the need as “there is too much damage to bumpers in low-speed collisions.” That should give you more flexibility in exploring alternative design approaches.”
1. So we are Identifying the client
2. Working from the Client’s perception of the need
   Asking: Why is this a need?
   Trying to: Identify the reason for the need
## Step 2: Defining the Problem

<table>
<thead>
<tr>
<th>Goal Statement</th>
<th>Idealized and scope still poorly delineated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Objectives</td>
<td>Each is unambiguous and measurable</td>
</tr>
<tr>
<td>Constraints</td>
<td>Each is unambiguous and measurable, clearly satisfied or violated. Hard requirements; cut down the feasible set</td>
</tr>
<tr>
<td>Design Criteria</td>
<td>Compact descriptor: useful for first-pass analysis of alternative approaches</td>
</tr>
</tbody>
</table>
Step 2: Defining the Problem: Goal

- Now we try to produce a Goal Statement
- Sets out to answer the question “How are we going to address this Need?”
- Brief, general, and ideal response to the Need.
- At this stage: Is so ideal that it might never be achieved, or so general that we cannot determine when it is achieved.
  - Its selection establishes the general direction of the design effort.
  - Don’t yet have readily identifiable closure.
Step 2: Defining the Problem: Goal

- Goal Statement scope is often not clear initially.
- Statement needs to be understood by the client.

**Example:**

**Need:** Childproof pill bottles are too difficult for people with arthritis to open.

**Possible goal statements:** *Design a –*

- Childproof pill bottle that is easier to open
- Childproof pill container that is easier to open
- Childproof system for dispensing pills
- Childproof system for dispensing medication
Step 2: Defining the Problem: Goal

Unavailable Design Options

Goal not selected

Goal

Available Design Options
Step 2: Defining... Objectives

- Quantifiable expectations of performance.
- Establish operating environment.
- Indicators of progress toward achieving Goal.
- Define the performance characteristics of the design that are of most interest to the client.
- Facilitate determination of which alternative designs best meets expectations.
Step 2: Defining... Objectives

Examples from the bumper problem:

- inexpensive
- no significant damage to bumper
- no significant damage to other parts
- easily recyclable
- operative

Revised Need: There is too much damage to cars in low-speed collisions
Revised Goal: Design an improved front bumper
## Step 2: Defining... Objectives

<table>
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<tr>
<th>Objective</th>
<th>Measurement Basis</th>
<th>Units</th>
</tr>
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<tbody>
<tr>
<td>Inexpensive</td>
<td>Unit manufacturing cost for a production run of 50,000</td>
<td>dollars</td>
</tr>
<tr>
<td>No significant damage to bumper</td>
<td>Distance bumper is pushed into body</td>
<td>inches</td>
</tr>
<tr>
<td>No significant damage to other parts</td>
<td>Repair cost</td>
<td>dollars</td>
</tr>
<tr>
<td>Easily recyclable</td>
<td>Amount of aluminum</td>
<td>lb</td>
</tr>
<tr>
<td>Retain maneuverability</td>
<td>Turning radius</td>
<td>ft</td>
</tr>
<tr>
<td>Retain braking capability</td>
<td>Braking distance</td>
<td>ft</td>
</tr>
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Step 2: Defining... Constraints

Constraints establish permissible range of the design and performance parameters.

Three types:

1. yes/no constraints (or go/no-go)
   e.g., must use 3/8”-24 UNF SAE grade 5 bolts

2. equality constraints
   e.g., must be 18” high

3. inequality constraints (single and double sided)
   e.g., cannot weigh more than 50 lb, must hold at least 50 lbs of steam,
   must be between 12” and 15” long
Aside: Objective-Constraint Duality

Restating the problem in a slightly different way can result in some objectives becoming constraints and vice-versa.

- The **objective** “not causing significant damage” can be reworded as a **constraint** “not costing more than $200 to repair”.
- It may be desirable to include both in the problem statement.
  - Or at least think about which is the better form.
  - Think: landscape gradient vs. bounds.
**Step 2: Defining... Criteria**

- **Objectives**: Quantifiable expectations of performance
- **Criteria**: Value-free descriptor of objective
  
  *Same units; same basis for measurement*

**Example:**
  
  Design objective: should be lightweight
  Associated criterion: weight

Criteria are compact descriptors of performance associated with objectives.

Criteria can be developed from approaches. They allow you to think about common and unique features.
## Step 2: Defining... Criteria

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