XXX 487 SENIOR DESIGN PHASE I

Project Specifications, Design Criteria, & Design Selection
Project Specifications

- Developed from project description and client/customer/stakeholder requirements
- Provide precise description of what the design has to accomplish
- Types of
  - Design (performance)
    - Feasibility
    - Merit
  - Construction (detailed)
    - Model or Prototype
    - Manufacturing
Project Specifications
Design (performance) Specifications

- Measurable statements of the objectives that a design must achieve [each one a metric and a value].
- Developed early in the design process
- Requires input from:
  - potential clients, marketing personnel, potential clients, marketing personnel,
  - investors, manufacturing specialists,
  - legal experts, management,
After a decision has been made to proceed with the build and test phase

Written and visual communications

Prototype phase construction details
- Location, Size, Tolerances,
- Material Type, Surface Finishes, etc

Manufacturing phase construction details:
- Assembly Techniques, Assembly Techniques,
- Packaging, Packaging,
- Shipping Instructions, etc
Design Criteria

- Developed from specifications to
  - Ensure compliance with client’s requirements
  - Discriminate between design alternatives
  - Identify a ‘best’ feasible design

- Two Types
  - Feasibility Criteria Feasibility
    - Eliminate infeasible designs
  - Merit Criteria
    - Identify characteristics of ‘best’ design
Design Criteria

Feasibility Criteria

- Factors that limit the scope of a project
  Normally expressed as constraints
  - unit must weigh less than 100 lbs.
  - unit must accelerate to a velocity of 60 mph in less than 10 seconds.

- Go / No Criteria
  - (Feasible / Not-Feasible)

- Project Specifications are a primary source
Choosing the ‘Best’ Design

- Usually one of three ways with Merit Design Criteria
  - Clearly one feasible design may be best all around
    - Better priced
    - Better sized
    - Better performance
  - An engineering discussion of the important differences in designs pointing to the best choice
    - Uses processor you are familiar using
    - More robust design, longer life,
    - Can be made more easily
  - Numerical Merit Analysis of the designs when no obvious best design
Design Criteria

Merit Criteria

- Factors that promote discrimination between FEASIBLE design alternatives.
- Provides a logical method for selecting the "best" feasible design alternative.
- Should be presented in a form which will easily facilitate the decision making process [easily measureable]
Design Criteria

Merit Criteria:

- Specific while still providing a basis for choosing between alternatives. Examples include:
  - Low unit production cost, low shipping cost, low storage cost, etc.
  - High acceleration, high velocity, high efficiency, etc.
- Project Specifications with interval or inequality values are good starting point
  - Ask: What is the overall project goal?
Design Criteria

- Design Specification
- Feasibility Criteria
- Merit Criteria
Design Criteria: Race Car

- **Design Specification**
  - 2017 Stock model car for NASCAR
  - Use titanium rocker arms, as light as possible
  - 0-60 MPH speed in or under 4 sec.

- **Feasibility Criteria (go/no go)**
  - Safety requirements
  - Must meet all race rules
  - Use titanium rocker arms
  - 0-60 MPH speed in 4 sec

- **Merit Criteria**
  - More HP is better
  - Less weight is better
  - Fuel efficiency is desired
  - 0-60 MPH speed in < 3.99 sec
  - Weight of Use titanium rocker arms
Feasibility Analysis

- Eliminate some of the design concepts
- Reveal ways that other alternatives may overcome their limitations
- Produces at least two feasible alternatives
  - In practice, this may not always occur
  - For senior design groups: your project must have at least two feasible alternatives [consider variations in functions, materials, features, etc.]
- A single table comparing each design to the feasibility criteria with pass/fail (√ or X) notation is a common approach
  - Good visual of why designs are succeeding or failing
Numerical Merit Analysis

- **Structured way** to make a logical, documentable decision concerning the *"best" design alternative*
- It is not a "foolproof" way of selecting the best design.
- Also applies to problem solution, manufacturing process, product supplier, etc.

- **If you can objectively discuss alternatives and clearly show a design or design feature is the best, a numerical merit analysis on that design or feature is not necessary.**
Numerical Merit Analysis, cont’d

- Provides a point of departure for engaging in intelligent debate over design decisions
- Shows why one of the alternatives was selected over the others
- Provides basis for retracing the steps that led to the decision
- Better than simply declaring victory based on some sort of "gut feeling"
Numerical Merit Analysis Steps

1. Determine Criteria Importance
2. Develop Merit Curves
3. Merit Factor Assignment
4. Calculations
1. Criteria Importance

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Points</th>
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<tr>
<td>Functionality</td>
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<td>Production cost</td>
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<td>Operating cost</td>
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<tr>
<td>System weight</td>
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</tr>
<tr>
<td>Aesthetics</td>
<td>5</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>
2. Develop Merit Curves

Operating Cost

Merit Factor vs. Cost (dollars)

Functionality

Merit Factor vs. Functionality
3. Merit Factor Assignment

Operating Cost

M.F. = 6

Functionality

M.F. = 7

Feature Attribute = $2/hr

Feature Attribute = 7
4. Calculation Step One

- Calculate merit associated with each criterion for each design
- criterion merit = (weight) x (merit factor)
5. Calculation Step Two

- Calculate total merit associated with each design
- Total merit = Sum of (criterion merit) for all criteria
Example

<table>
<thead>
<tr>
<th>Feature Attribute</th>
<th>Weight (%)</th>
<th>Merit factor</th>
<th>Total Merit</th>
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<tbody>
<tr>
<td>Functionality</td>
<td>40</td>
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<tr>
<td>Production cost</td>
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<td>180</td>
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<tr>
<td>Total</td>
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<td>625</td>
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Making a Decision

Discuss the scoring of the designs and consider:

- What would a ‘perfect’ design score?
- How different are the numbers?
- Which merit criteria are making the biggest difference?
- Is one merit criterion driving the decision?
- Can the merit criterion, weighting, curves, etc. be improved?
### Example

#### Alternative #1

<table>
<thead>
<tr>
<th>Feature Attribute</th>
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<tr>
<td>7</td>
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<tr>
<td>$1000/unit</td>
<td>6</td>
<td>180</td>
</tr>
<tr>
<td>$2.00/hr</td>
<td>6</td>
<td>90</td>
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<tr>
<td>60 lbs</td>
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Total Merit: 625

#### Alternative #2

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<td>30</td>
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<tr>
<td>70 lbs</td>
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<td>35</td>
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Total Merit: 685

#### Alternative #3

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<tr>
<td>50 lbs</td>
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</tr>
<tr>
<td>25</td>
<td>5</td>
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Total Merit: 715
Comments and Discussion