Clarification on Cost Analysis

- Direct materials + direct labor for final design
- DO try to estimate unit cost for the volumes consistent with your project objectives
- DO NOT estimate costs that are outside of your project scope (e.g., cost of purchasing manufacturing equipment)
Engineering Failures

http://www.youtube.com/watch?v=HxTZ446tbzE&feature=related

Tacoma Narrows Bridge Collapse

http://www.youtube.com/watch?v=3mclp9QmCGs&NR=1
I-35W Bridge Collapse
Minneapolis, MN

photo
The Royal Mail Ship Titanic: Did a Metallurgical Failure Cause a Night to Remember?

Katherine Felkins, H.P. Leighty, Jr., and A. Jankovic

INTRODUCTION

In the early part of this century, the only means of transportation for travelers and mail between Europe and North America was by passenger steamship. By 1907, the Cunard Steamship Company introduced the largest and fastest steamers in the

A metallurgical analysis of steel taken from the hull of the Titanic’s wreckage reveals that it had a high ductile-brittle transition temperature, making it unsuitable for service at low temperatures; at the time of the collision, the temperature of the sea

and Wolff, met with J. Bruce Ismay, managing director of the Oceanic Steam Navigation Company, better known as the White Star Line (a name taken from its pennant). During this meeting, plans were made to construct three enormous new White Star liners to compete with the Lusitania and Mauretania on the North Atlantic by establishing a three-ship weekly steamship service for passengers and mail between Southampton,
Hyatt Regency Walkway Collapse, Kansas City
Good engineering designs are robust to failure.
Failures Occur on 3 Levels

3: Attitude / Perspective
   e.g., overconfidence, apathy, bad priorities, laziness, unethical behavior

2: Process Errors
   e.g., miscalculation, poor assumptions, incomplete data, fabrication, miscommunication…

1: Physical Flaws
   e.g., overload, fatigue, corrosion….
Proactive vs. Reactive

**Failure Analysis** = analyzing an event that’s already happened

**Hazards Analysis** = analyzing possible failures in advance
General Methodology

1. Review existing standards
2. Identify known hazards
3. Identify “unknown” hazards
   – “hidden” or non-obvious
4. Analyze the hazards
   – probability / frequency, severity
General Methodology, cont.

5. Eliminate or minimize the hazard
   – safety features
   – safety factors
   – administrative controls
Two Tools

- Fault Tree Analysis
- Failure Modes and Effects Analysis (FMEA)
Fault Tree Analysis

Top down approach to identify the underlying causes of an undesirable event.

Symbols

- Fault Event
- Basic Fault
- AND
- OR
FTA Example
Failure Modes and Effects Analysis

1. Focus on one component/system at a time
2. Brainstorm ways component could fail
3. Identify the consequences of failure, severity and probability
4. Propose design modifications

“Bottom Up”
### FMEA Example: Pressure Vessel

<table>
<thead>
<tr>
<th>Component</th>
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<th>Effect</th>
<th>Severity</th>
<th>Probability</th>
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<th>Design Mod’s</th>
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- **Effect**
  - Water loss
  - Flood

- **Severity**
  - Minor

- **Probability**
  - Mod.

- **Detection Method**
  - Insp.

- **Design Mod’s**
  - Add floor drain
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<td>Pressure Relief</td>
<td>Shut</td>
<td>Explosion</td>
<td>V. Severe</td>
<td>Low</td>
<td>None</td>
<td>Add second valve</td>
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Conclusion

• “A fellow who makes no errors is a fellow who doesn’t do much.”
  – former Detroit Tigers baseball coach

• Important to learn from failures.
  – Your own
  – Others
  – To Engineer is Human, by H. Petroski