The Product Development Process

- Trade Study and Down Selection

Winners: Round 1

Design 6: 8.2
Design 4: 7.9
Design 2: 8.0
The Product Development Process

- **Trade Study and Down Selection**

<table>
<thead>
<tr>
<th>Design 6</th>
<th>Design 4</th>
<th>Design 22</th>
</tr>
</thead>
<tbody>
<tr>
<td>bulk</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>complexity</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>user-friendly</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Totals</td>
<td>2.0</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Possible re-design?
The Product Development Process

• Preliminary Design

**ODS Baseline Concept**

**Baseline Dimensions:**
- \( M = 0.15L \)
- \( N = 0.10L \)

Also:
- Infrared thermography cameras on back side mast?
- Piezoelectric actuators for dynamic excitation?

**Front (sun) side of the sail**

1. 4 front-side 90-deg FOV camera clusters (16 cameras)
2. 1 front-side inspection camera cluster with pan-tilt (3 cameras)
3. 4 cameras at hub, one looking down each boom (4 cameras)
4. 3 accelerometers at each boom tip (x & y bending, torsion)
5. Boom root strain sensors
6. Membrane tension sensors
The Product Development Process

• Preliminary Design
The Product Development Process

• Detailed Design

Structural analysis, thermal analysis, fluid analysis, kinematic analysis, …

Interface design

Design for manufacturing, design for assembly

Test and validation

FMEA
# The Product Development Process

## Failure Modes and Effects Analysis (FMEA)

**FMEA - Quick Reference Guide**

<table>
<thead>
<tr>
<th>Item</th>
<th>Function</th>
<th>Potential Failure Mode</th>
<th>Potential Effects of Failure</th>
<th>Potential Causes of Failure</th>
<th>Control Measures</th>
<th>Control Measures</th>
<th>Recommended Actions</th>
<th>Action Taken</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Product liability</td>
<td>Product liability</td>
<td>Design error, component failure</td>
<td>Component selection, supplier quality</td>
<td>Design verification, component selection</td>
<td>Design verification, component selection</td>
<td>Design verification of component selection</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td>Safety</td>
<td>Safety</td>
<td>Failure to meet safety standards</td>
<td>Product design, manufacturing process</td>
<td>Design verification, component selection</td>
<td>Design verification, component selection</td>
<td>Design verification of component selection</td>
<td>2</td>
</tr>
<tr>
<td>3</td>
<td>Reliability</td>
<td>Reliability</td>
<td>Failure to meet reliability standards</td>
<td>Material properties, manufacturing process</td>
<td>Design verification, component selection</td>
<td>Design verification, component selection</td>
<td>Design verification of component selection</td>
<td>3</td>
</tr>
</tbody>
</table>

**Potential Critical & Significant Characteristics’ Action Guidelines**

1. **Failure Modes**
   - Review and update the FMEA as necessary
   - Address high-risk potential failure modes first
   - Use a cross-functional FMEA team approach

**For FMEA assistance call:**

(913) 986-9776 x242

www.asginc.com

To learn more about FMEA-EXPRESS™ call:

(913) 986-9776 x242

www.asginc.com
The Product Development Process

• Final Design and Development

Table 8. CRT and TriLok Requirements Compliance

<table>
<thead>
<tr>
<th>NRA</th>
<th>CRT Value</th>
<th>Method</th>
<th>CRT Value</th>
<th>Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length</td>
<td>30m</td>
<td></td>
<td>50m</td>
<td>Design</td>
</tr>
<tr>
<td></td>
<td>8.5m</td>
<td>Built</td>
<td>7m</td>
<td>Built</td>
</tr>
<tr>
<td>Scalable</td>
<td>&gt;100m</td>
<td>&gt;100m</td>
<td>&gt;100m</td>
<td>Assess</td>
</tr>
<tr>
<td>Boom Mass</td>
<td>&lt;75 g/m</td>
<td>60 g/m</td>
<td>Measured</td>
<td>68 g/m</td>
</tr>
<tr>
<td>Bending Stiffness</td>
<td>1000 Nm²</td>
<td>1400 Nm²</td>
<td>Tested</td>
<td>1500 Nm²</td>
</tr>
<tr>
<td>Packing Factor</td>
<td>&lt;10</td>
<td>&lt;8 @ 30m</td>
<td>Measured</td>
<td>&lt;10 @ 30m</td>
</tr>
</tbody>
</table>
CUSTOMER REQUIREMENTS:
• Functional specifications (CRR)
• Project constraints

DESIGN:
• Preliminary (PDR)
• Detailed (CDR)

DELIVERABLES:
• Product (PRR)
• Archival information

CRR = Customer Requirements Review
PDR = Preliminary Design Review
CDR = Critical Design Review
PRR = Project Readiness Review
The ME 403 Design Process

**Problem Definition**

Tasks:
* Clarify design objectives
* Establish design requirements
* Identify constraints
* Establish functions

Deliverables:
* Need Statement
* *Introduction, Statement of Work*

**Project Management**

Tasks:
* Task and resource identification
* Task and resource scheduling
* Cost control
* Team building
* Documentation

Deliverables:
* Project Schedule
* Progress Report
* Self-evaluation form

**Preliminary Design**

Tasks:
* Background research
* Concept generation
* Concept selection
* Concept design

Deliverables:
* *Preliminary Design*

**PDR**

Customer Need
### The ME 403 Design Process

<table>
<thead>
<tr>
<th><strong>Project Management</strong></th>
<th><strong>Detailed Design</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tasks:</strong></td>
<td><strong>Tasks:</strong></td>
</tr>
<tr>
<td>* Task and resource identification</td>
<td>* Total structural design</td>
</tr>
<tr>
<td>* Task and resource scheduling</td>
<td>* Loads analysis</td>
</tr>
<tr>
<td>* Cost control</td>
<td>* Materials selection</td>
</tr>
<tr>
<td>* Team building</td>
<td>* FMEA</td>
</tr>
<tr>
<td>* Documentation</td>
<td></td>
</tr>
<tr>
<td><strong>Deliverables:</strong></td>
<td><strong>Deliverable:</strong></td>
</tr>
<tr>
<td>* Progress Report</td>
<td>* FMEA</td>
</tr>
<tr>
<td>* Self-evaluation form</td>
<td>* Test/validation plan</td>
</tr>
<tr>
<td></td>
<td>* Detailed Design section</td>
</tr>
</tbody>
</table>