16.810
Vehicle Design Summit Team 1
Ingress/Egress
Design System  Analysis and Optimization  Fabrication
Objective:

Multi-Objective problem

Quantifiable Criteria
- Cost ($)
- Visibility (sq. m)
- Egress Ingress (sec)

Unquantifiable Criteria
- Ease of Manufacturability
- Aesthetics
Design System

Constrains:
- Shape of existing Shell (m)
- Weight (Kg)
- Cost ($)

Design Variables:
- Geometry (Number and positions of Joints)
- Material (Transparency/Opaque)
- Kinematics (Hinge, Slider..etc)
Design System

Concept
Design System

AHPV Design Space

Design Solution Tree:
Fabrication Analysis and Optimization Design System
Design System
Design System
Design System
Design System

Fabrication
Analysis and Optimization

Test 1 – ‘Hard Opening’
- Highest dynamic load when someone opens canopy and pins hit end of rails
- Force of $2g \times$ mass of canopy $\sim 11$ pounds
- Restraints of fixed edges roughly equivalent to final design
- Stress concentrated around joint
- Displacements acceptable
Analysis and Optimization

Test 2 – ‘Driving Pressure Force’
  • Pressure on canopy while driving 60mph ~550N/m²
  • Restraints of fixed edges based on magnetic strips
  • Natural modes at low freq – first mode at 0.5Hz
  • Canopy displacement ~3mm max at 60mph
Analysis and Optimization

Test 3 – ‘Rail Optimization’

• Varied thickness of rail to find optimum size to avoid yield at min mass
• Force of 40N side load – someone leaning on canopy

<table>
<thead>
<tr>
<th>Thickness (inches)</th>
<th>FoS</th>
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<tbody>
<tr>
<td>1</td>
<td>8.9</td>
</tr>
<tr>
<td>0.5</td>
<td>2.7</td>
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<tr>
<td>0.25</td>
<td>2.0</td>
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</table>

• We tried to use a thicker sandwich material – delaminated
• Now using 0.25 inch aluminium, slightly different rail design
Analysis and Optimization

Local Trend Plot of Objective

Design Variable Vs Design Set

Design System  Analysis and Optimization  Fabrication
Analysis and Optimization
Fabrication

Canopy – Ordered from professional manufacturer in Florida
Handles – Aluminium tube welded onto waterjetted guide rails
Rails – Aluminium, waterjet, attached by U-Clamp
Attachment – Adhesive backed magnetic strip
Fabrication Analysis and Optimization Design System
Fabrication
Fabrication
Fabrication Analysis and Optimization Design System
What’s Next…?

- Handles welded to rails
- Attach rail to chassis
- Sand shell and canopy
- Reinforcing canopy
- Attaching canopy to reinforcement
- Attaching reinforced canopy to handles
- Test mechanism, fix problems!
- Stick on magnetic strips so canopy stays shut
- Drive AHPV to Solidworks World
- Sleep…
## 16.810 Cost Estimation Sheet
### Team V1

<table>
<thead>
<tr>
<th>Section</th>
<th>Rate</th>
<th>Qty</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td><strong>I. Design and Engineering</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Labor Rate for Each Designer</td>
<td>$75</td>
<td>10</td>
<td>$750</td>
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<tr>
<td>Labor Rate for Each CAD/CAM Workstation</td>
<td>$40</td>
<td>5</td>
<td>$200</td>
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<tr>
<td><strong>II. Materials Cost</strong></td>
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<tr>
<td>Aluminium Sheet, 1/16&quot; thick</td>
<td>$40</td>
<td>1</td>
<td>$40</td>
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<tr>
<td>Aluminium Tube, 1/4&quot; thick</td>
<td>$80</td>
<td>1</td>
<td>$80</td>
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<tr>
<td>Miscellaneous Components</td>
<td>$60</td>
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<td>$60</td>
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<td><strong>III. Canopy</strong></td>
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<tr>
<td>Canopy</td>
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<tr>
<td>Shipping</td>
<td>$200</td>
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<td>$200</td>
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<tr>
<td><strong>IV. Waterjet Manufacturing</strong></td>
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<td>Labor Rate</td>
<td>$55</td>
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<tr>
<td>Machine Use</td>
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<td>$225</td>
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<td><strong>V. Other Manufacturing</strong></td>
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<tr>
<td>Shell and Canopy Cutting - Labor</td>
<td>$40</td>
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<td>Miscellaneous Labor</td>
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<td><strong>VI. Assembly and Testing</strong></td>
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<td>Assembly Labor</td>
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<tr>
<td><strong>TOTAL</strong></td>
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<td>$2,580</td>
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*Design System*  *Analysis and Optimization*  *Fabrication*
Lessons Learned

- Set realistic goals
- Better use of FEA for optimization – our rail could have been designed to be lighter
- Start manufacturing early, maybe finish on time
- Have the right tools
- Make the right decisions at the right time

To be continued…