LOG HANDRAIL ASSEMBLY DEVICE
OUR TEAM

• LeAnne Cossairt

• JP Holcomb

• Joaquin Nungaray

• Jennifer Tourtillott

OUR ADVISOR: Dr. Mike Ward
PROBLEM STATEMENT

Segal Woodshop fabricates “residential market” type handrails from two pre-manufactured rails and a set of balusters. The assembly process is very labor intensive and time consuming. The function of the device will be to improve the assembly process of the log handrails by decreasing time and manual labor.
QUANTITATIVE REQUIREMENTS

• Single operator assembly
  – One operator for assembly process

• Quick assembly time
  – Average assembly time of 5 minutes or less for one unit

• Device must be adjustable for rails
  – 6’-12’ length rails in 1’ increments

• Device must be adjustable for balusters
  – Heights of 23”-32”

• Successful assembly of balusters into rails
  – OLD DEFINITION: Balusters on each unit must protrude at least ¾” into predrilled 1” deep holes. (6” on center and 1 ½” diameter holes)
  – NEW DEFINITION: Each assembled rail must measure no taller than the height of the baluster being assembled plus 6” ± 1/8”. If this height is met, the rail will be successfully assembled
QUALITATIVE REQUIREMENTS

• Must be mobile within workshop
  – 2 persons must be able to move device

• Device must not be too big for workshop
  – dimensions of device should not exceed 15’x8’x8’

• Device must restrict handrail components
  – Balusters and rails must be secured while under compressive loading

• Must be fully controllable by operator
  – Operator must be able to stop and reverse cylinder actuation at any time

• Components must be easily serviceable
  – Components that have the need for routine maintenance or replacement must be accessible
DESIGN SOLUTION

Completed Log Handrail Assembly Device
DESIGN SOLUTION

Video Demonstration
DESIGN SOLUTION

Parts of the Log Handrail Assembly Device

- Cylinder & Support Arm
- Linear Slide Bearing Housing
- Pneumatic Cylinder Hard Stop
- Upper Rail Support
- Baluster Guides/Supports
- Safety Bar
- Lower Rail Support
- Rail Adjustability Bracket
- Top Rail Alignment

Holcomb
DESIGN SOLUTION

Adjustability

Baluster Guide & Mount

Bottom Rail Adjustable Support

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Alignment

Top Rail Alignment

Baluster Guide

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Safety

Limit Switch

Safety Bar

Control Box
DESIGN SOLUTION

Air and Electrical Systems
DESIGN SOLUTION

Air System Components

Solenoid Valves and Manifold
Pressure Regulator w/ Air Filter
Pneumatic Cylinder
FABRICATION

1500 Fab Hours
TESTING

• Testing Procedures
  – All testing was done in PLMS 121
  – The qualitative requirements were tested by observation.
  – To confirm compliance with our quantitative requirements, twelve handrails were assembled according to the assembly process.
ASSEMBLY PROCESS

1. Adjust bottom rail for appropriate baluster height
2. Lift safety bar & lock top rail alignment mechanism
3. Load bottom rail
4. Load balusters into clamps
5. Place top rail on top of balusters
6. Unlock top rail alignment mechanism
7. Ensure that each baluster is approximately aligned with its top rail hole
8. Lower safety bar
9. Press green start button
10. Allow pneumatic cylinders to compress log handrail
11. Press red stop button to reverse cylinders
The set of test data in the table below provide test results for each of the quantitative requirements.

(i.e. rail length, baluster height, time to assemble, # of operators and the successful assembly)

<table>
<thead>
<tr>
<th>Trial</th>
<th>Rail Length</th>
<th>Baluster Length</th>
<th>Time</th>
<th>A</th>
<th>B</th>
<th>Successful Press Fit?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>12'</td>
<td>31&quot;</td>
<td>2min46sec</td>
<td>37 1/8&quot;</td>
<td>37 1/8&quot;</td>
<td>Yes</td>
</tr>
<tr>
<td>2</td>
<td>12'</td>
<td>31&quot;</td>
<td>2min4sec</td>
<td>37&quot;</td>
<td>37&quot;</td>
<td>Yes</td>
</tr>
<tr>
<td>3</td>
<td>12'</td>
<td>31&quot;</td>
<td>3min33sec</td>
<td>37&quot;</td>
<td>37&quot;</td>
<td>Yes</td>
</tr>
<tr>
<td>4</td>
<td>12'</td>
<td>31&quot;</td>
<td>2min52sec</td>
<td>37 1/16&quot;</td>
<td>37 1/16&quot;</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>12'</td>
<td>31&quot;</td>
<td>1min54sec</td>
<td>37&quot;</td>
<td>37&quot;</td>
<td>Yes</td>
</tr>
<tr>
<td>6</td>
<td>8'</td>
<td>31&quot;</td>
<td>3min6sec</td>
<td>37&quot;</td>
<td>36 7/8&quot;</td>
<td>Yes</td>
</tr>
<tr>
<td>7</td>
<td>6'</td>
<td>31&quot;</td>
<td>3min24sec</td>
<td>36 13/16&quot;</td>
<td>36 13/16&quot;</td>
<td>Yes</td>
</tr>
<tr>
<td>8</td>
<td>12'</td>
<td>25&quot;</td>
<td>4min36sec</td>
<td>31 1/8&quot;</td>
<td>31 1/4&quot;</td>
<td>No</td>
</tr>
<tr>
<td>9</td>
<td>8'</td>
<td>25&quot;</td>
<td>4min5sec</td>
<td>31 1/16&quot;</td>
<td>31 1/4&quot;</td>
<td>No</td>
</tr>
<tr>
<td>10</td>
<td>8'</td>
<td>25&quot;</td>
<td>4min10sec</td>
<td>31 1/16&quot;</td>
<td>31 1/16&quot;</td>
<td>Yes</td>
</tr>
<tr>
<td>11</td>
<td>6'</td>
<td>25&quot;</td>
<td>4min15sec</td>
<td>30 15/16&quot;</td>
<td>30 15/16&quot;</td>
<td>Yes</td>
</tr>
<tr>
<td>12</td>
<td>6'</td>
<td>25&quot;</td>
<td>3min19sec</td>
<td>30 3/4&quot;</td>
<td>30 7/8&quot;</td>
<td>Yes</td>
</tr>
</tbody>
</table>
TEST RESULTS (CONT.)

- The table below shows compliance to the overall dimensions requirement. The LHAD must fit into a 15’x8’x8’ box

<table>
<thead>
<tr>
<th>Device Dimensions</th>
<th>Requirement Met?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length = 12ft 8in</td>
<td>Yes</td>
</tr>
<tr>
<td>Height (Safety Bar Closed) = 7ft 7 1/2in</td>
<td>Yes</td>
</tr>
<tr>
<td>Height (Safety Bar Open) = 8ft 6in</td>
<td>No</td>
</tr>
<tr>
<td>Width = 3ft 7 3/4in</td>
<td>Yes</td>
</tr>
</tbody>
</table>

- Results for the rest of the qualitative requirements

<table>
<thead>
<tr>
<th>Qualitative Requirements</th>
<th>Requirement Met?</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Components that require routine maintenance</td>
<td>Yes</td>
</tr>
<tr>
<td>and/or replacement must be accessible</td>
<td></td>
</tr>
<tr>
<td>2. Balusters and rails must be secured while</td>
<td>Yes</td>
</tr>
<tr>
<td>under compressive loading</td>
<td></td>
</tr>
<tr>
<td>3. Operator must be able to stop and reverse</td>
<td>Yes</td>
</tr>
<tr>
<td>the assembly process at any time</td>
<td></td>
</tr>
</tbody>
</table>

Cossairt
## BUDGET

<table>
<thead>
<tr>
<th>Description</th>
<th>~</th>
<th>$2,000.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Components</td>
<td>~</td>
<td>$2,000.00</td>
</tr>
<tr>
<td>Hardware</td>
<td>~</td>
<td>$450.00</td>
</tr>
<tr>
<td>Material</td>
<td>~</td>
<td>$1,250.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$3,700.00</strong></td>
</tr>
</tbody>
</table>

### LABOR (2000 HOURS)

<table>
<thead>
<tr>
<th>Description</th>
<th>~</th>
<th>$2,000.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salary ($33.58/hr)</td>
<td>$33.58</td>
<td>$67,160.00</td>
</tr>
<tr>
<td>Benefits (37% hourly rate)</td>
<td>$12.42</td>
<td>$24,849.20</td>
</tr>
<tr>
<td>Overhead (40% hourly rate)</td>
<td>$13.43</td>
<td>$26,864.00</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>$118,873.20</strong></td>
</tr>
</tbody>
</table>

**Total Cost w/ Labor:** $122,573.20

Nungaray
UNIQUE PROBLEMS ENCOUNTERED

• Offset top rail assembly
  - Cylinder mount spacer

• Deflection
  - Structural reinforcements added

• Binding of bottom rail assembly
  - Removed guides and bearings

• Removal of completed handrail
  - Added hinge locking mechanism

• Space and time to fabricate
  - Utilized open lab access hours
  - Baja team
  - PLMS 121

Nungaray
FUTURE OF THE L.H.A.D.

• Recommendations
  – Design Changes
    • Clamp design
    • Less range of fastener sizes
    • Increased tolerances on linear guides
    • Bolt together assembly
    • Improved design of cylinder brackets

• More Log Handrail Assembly Devices?
THANK YOU!

• Rafi Segal and Segal Woodshop
• Dr. Mike Ward (Project Advisor)
• Parker-Hannifin, Racor Division
  – Donation of pneumatic cylinders
• Igus Incorporated
  – Donation of top-rail alignment components
• For Fabrication Assistance
  – Scott Brogden (MFGT) – lab access
  – Jeff Ferrara and SME students – welding and advice
  – Leonard Fallscheer (MFGT) – CNC assistance
  – Steve Eckart (ECC) – air systems and circuitry assistance
  – Mike Renwick and Andrew Libby – fab of aluminum parts
QUESTIONS?

LeAnne Cossairt  JP Holcomb  Joaquin Nungaray  Jennifer Tourtillo