**Introduction**

**Problem Statement:**
- To design a versatile tie-rod that can be adjusted to change the tread width of the machine with ease.

**Background:**
- Different row crops require various row spacing and in order to prevent customers from having to purchase separate tie-rods for each row spacing they require, an adjustable tie-rod will be implemented.

**Criteria:**
- Must fit within the given space-claim
- Must withstand high-buckling loads from steering dynamics
- Must perform safely under high tension and compression loads
- Must deliver precise adjustments of 4 inch increments

**Alternative Solutions**

<table>
<thead>
<tr>
<th>Design #1</th>
<th>Removable Midsection</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design #2</td>
<td>Overlapping Joints</td>
</tr>
<tr>
<td>Design #3</td>
<td>Boxed Midsection</td>
</tr>
<tr>
<td>Design #4</td>
<td>Hydraulic Cylinders</td>
</tr>
</tbody>
</table>

**Societal Impacts & Sustainability**

**Benefits:**
- Customer can have access to many different tread settings while only purchasing one tie-rod
- Ease of adjustment of tie-rod will create the customer more uptime
- Requires less material than the current option
- Allows the company to invest in the production of 1 tie-rod assembly vs. the production of several

**Disadvantages:**
- Leakage of hydraulic fluid in hydraulic design may have negative environmental impacts
- Rusting of steel, especially bolt holes in mechanical designs, may decrease the overall lifetime of the tie-rod

**Economical Analysis of Design #2**

<table>
<thead>
<tr>
<th>Cost of Material:</th>
<th>$1,160</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of custom machining:</td>
<td>$17</td>
</tr>
<tr>
<td>Cost of Forging:</td>
<td>$53</td>
</tr>
<tr>
<td><strong>TOTAL cost per part:</strong></td>
<td><strong>$1,230</strong></td>
</tr>
</tbody>
</table>

*Assume 1,000 parts produced in total

**Final Solution**
- The team's final recommended solution to the given problem statement is Design #2: Overlapping Joints
- The material selected for the final solution is Armstrong Ultra 960 steel
  - Provides F.S. = 1.2, given analysis results
- Why this solution was the best:
  - Stresses shown in analysis were allowable
  - Minimum parts required
  - Meets all design criteria
  - Cost effective

**Calculations & Analysis**

- Through a mid-design review, 2 alternative solutions were chosen to move forward with analysis
  - Design #2: Overlapping Joints
  - Design #4: Hydraulic Cylinders
- Hand calculations were performed on both models to get the following results:
  - Buckling loads
  - Deflection
  - Bolt Shear Stress
- Creo FEA was also performed on both models and the results were comparable to the hand calculations
- Through analysis, several iterations were made to both Design #2 and #4