Update on Potential BioRID Injury Criteria
## PMHS Injury Analysis
**IV-NIC vs. Kinematic Criteria**

<table>
<thead>
<tr>
<th></th>
<th>IV-NICrot</th>
</tr>
</thead>
<tbody>
<tr>
<td>R² - value</td>
<td></td>
</tr>
<tr>
<td>NDCrot</td>
<td>0.75</td>
</tr>
<tr>
<td>NDCx</td>
<td>0.48</td>
</tr>
<tr>
<td>NDCz</td>
<td>0.44</td>
</tr>
<tr>
<td>NIC</td>
<td>0.45</td>
</tr>
</tbody>
</table>
Potential BioRID Injury Criteria
ND\text{Crot}

PMHS Regression model

50\% chance of AIS 1+ injuries for PMHS
ND\text{Crot} = 32.5\ deg\ (flexion)

50\% chance of AIS 1+ injuries for BioRIDII
ND\text{Crot} : 12.2\ deg\ (flexion)

\begin{align*}
y &= 23.99x + 6.08 \\
R^2 &= 0.75
\end{align*}
Head Restraint Forces
Production Seats
Head Restraint Forces
Production Seats
Inherent issues with HR Contact Force Estimation

- Force of head contact is perpendicular to HR (x-direction)
  - No axial loading on the HR
  - Predicted HR force is very sensitive to HR contact height
  - Assumptions inherent to inverse dynamics analysis
• Analysis of BioRID HR contact force versus Fx skull cap load
Head Restraint Forces
Production Seats

- Analysis of BioRID HR contact force versus Fx skull cap load
  - Match for only 2 out of 7 tests
    - Large Fz skull cap (as much as 50% of Fx)
  - Algorithm to compensate strain gages for axial HR loads
    - 5 out of 7 tests matched
Analysis of BioRID HR contact force versus Fx skull cap load
- Match for only 2 out of 7 tests
  - Large Fz skull cap (as much as 50% of Fx)
  - Algorithm to compensate strain gages for axial HR loads
    - 5 out of 7 tests matched

PMHS → no way to estimate axial contribution
- Assume same Fz/Fx ratio as BioRID for given test condition
- Apply compensation algorithm
- Recalculate upper/lower neck loads
- Still no good correlations
PMHS Injury Analysis
IV-NIC vs. Upper/Lower Neck Loads

<table>
<thead>
<tr>
<th></th>
<th>Upper Neck</th>
<th>Lower Neck</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fx</td>
<td>Fz</td>
</tr>
<tr>
<td>+</td>
<td>0.72</td>
<td>0.14</td>
</tr>
<tr>
<td></td>
<td>0.01</td>
<td>0.09</td>
</tr>
<tr>
<td>-</td>
<td>0.02</td>
<td>0.51</td>
</tr>
<tr>
<td>+</td>
<td>0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>-</td>
<td>0.85</td>
<td>0.41</td>
</tr>
<tr>
<td>+</td>
<td>0.02</td>
<td>0.99</td>
</tr>
<tr>
<td>-</td>
<td>0.02</td>
<td>0.93</td>
</tr>
</tbody>
</table>

R - value | P - value
0.72 | 0.02
0.01 | 0.85
0.09 | 0.51
0.14 | 0.41
0.04 | 0.65
0.22 | 0.29
0.35 | 0.16
0.01 | 0.87
0.00 | 0.99
0.00 | 0.93
0.00 | 0.92
0.10 | 0.48

\[ y = 195.44x - 53.08 \]
\[ R^2 = 0.72 \]
Certify and upgrade BioRID dummies
- Incorporate design changes that improved reproducibility
- Ensure these dummies represent the future regulatory tool

1) Re-run 5 injury criteria sled tests (using both BioRIDs)
- Conduct all 5 tests in one week
- Refine injury criteria numbers
  - Improve direct correlations and intervertebral kinematics?
- Two dummies to check reproducibility
- Seats: Chevy Cruze and Toyota Camry (same as PMHS tests)
Conduct paired BioRID/Hybrid III sled tests

2) Extension tests → NDCrot criterion developed in production seats is flexion only
   - Use modified Chevy Cruze seat to create large backsets
   - All three pulses
   - 12 deg Hybrid III extension = ?? deg BioRID
Conduct paired BioRID/Hybrid III sled tests

3) Small-scale fleet assessment
   - Compare 202a criteria with HyIII to proposed BioRID criteria
   - All three pulses
   - Variety of seats (including active or re-active HR)
     - Chevy Cruze
     - Toyota Camry
     - Toyota Matrix
     - Ford F150
     - Honda Odyssey re-active HR seat (mechanically-induced)
Questions??