ARC Farside Meeting Update
Task 3: Carotid Artery

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Carotid artery modeling goals

- Computational model of the carotid artery for the prediction of injury
- What’s been done:
  - Develop a robust material model and mesh of the artery (Gayzik et al. RMBS, 2005)
  - Organ level validation of the material model (Gayzik et al. AAAAM 2006, Gayzik et al. ASB 2006)
- Currently:
  - Regional level neck model

FE model development strategy

1. Tissue Level
2. Organ Level
3. Update: Regional Level

Review: Regional neck model

Materials:
- Neck tissues & musculature
  - "Mat_Viscoplastic"
- Carotid
  - "Mat_Simplified_rubber"
- Indenter
  - "Mat_Rigid"

Contact:
- Neck to carotid
  - Auto surf to surf
- Neck to neck
  - Tied

Boundary:
- Locked nodes on axial stress and medial sections body space

Update: Regional Model Integration with NHTSA Neck

- Integration of NHTSA model of the head and cervical spine
- Application of MCW crash pulse on integrated model

Update: NHTSA neck model

Materials:
- Vertebral Bodies, Head
  - "Mat_Rigid"
- Ligaments, Diaks
  - "Mat_Elastic"

Boundary Conditions:
- Prescribed motion applied to T1 vertebral body

Contact:
- Posterior ligament to posterior aspect of the head
  - nodes to surface
- Head Rotation about an anterior/posterior axis
  - constrained joint revolute

Validation:
- Axial Compression: Good agreement with experimental data
  - Pinlar et al. Stapp, 1989 (Myers et al. Stapp 1991)
- Frontal Impact: Not favorable agreement
  - Wismans, STAPP, 1984 (Wismans, STAPP, 1987)

Lateral Flexion: No validation performed?
Neck Model Anatomy

Regional model simulation matrix

**Proposed Methods:**
- Apply T1 acceleration boundary condition
- Validate with belt force data

**Test matrix:**

<table>
<thead>
<tr>
<th>PMHS Test No.</th>
<th>Carotid Injury</th>
<th>Belt Position</th>
<th>ΔV</th>
</tr>
</thead>
<tbody>
<tr>
<td>134</td>
<td>No</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>135</td>
<td>Yes</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>140</td>
<td>Yes</td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td>141</td>
<td>Yes</td>
<td>High</td>
<td>High</td>
</tr>
</tbody>
</table>

PMHS Belt Placement

**Update: Combined neck model; MCW Load Curves**

**Materials:**
- Vertebral Bodies, Head
- "Mat_Rigid"
- Ligaments, Disks
- "Mat_Elastic"
- Neck fascia & musculature
- "Mat_Elastic"
- Carotid
- "Mat_Simplified_rubber"

**Boundary:**
- Prescribed motion from PMHS tests applied to T1 vertebral body

**Contact:**
- Preserve NHTSA neck contacts
- Top nodes of regional model to constrained to head
- Constrained extra nodes set
- Neck to carotid
- Tied surf to surf
- Neck vertebral bodies to neck fascia
- Auto surf to surf

Combined Neck Model, Low Delta-V
NHTSA Neck, High Delta-V Pulse

- Concerns:
  - Vertebral body nodal penetration
    - No contacts defined here
  - Facet nodal penetration
    - No contacts between facets
  - Negative volumes
    - Intervertebral Disks

Attempt to resolve by applying both T1 and Head CG as acceleration B.C.

NHTSA Neck, Other modeling concerns

Application of Head CG and T1: Resolve through THUMs Modeling
Low belt does not interact with neck: Resolve by adding a shoulder form

Oblique View: High Delta-V, High Belt

Frontal View: High Delta-V, High Belt

Spine: High Delta-V, High Belt

NHTSA Neck with THUMS vertebral body displacements
Summary of Update:

- Current modeling issues and tasks:
  Regional neck model with embedded carotid artery
  - NHTSA neck in lateral flexion
    • Contacts, negative volumes, kinematics
  - Belt interaction with the neck fascia
    • Belt slips off of neck given a low belt

Current Focus

- Integrate THUMs results into full neck model
- Add shoulder interaction structure for the low belt case
- Assess strain in the carotid

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Supplemental Slides

Regional model geometry
Superior view
Lateral view

Relative C-spine Heights
NHTSA
117.8 mm
THUMS:
142.2 mm