Effect of seating height in side impact

gtr Pole Side Impact, Washington 2012, 20-21 september
commissioned and presented by NL - MOT - RDW
Step 1: Comparison WorldSID - Human

Objective:

• Compare the response of the WorldSID to human responses

• By means of simulations of Wayne State University (WSU) tests at 6.7 and 9.1 m/s with MADYMO (facet) WorldSID model and MADYMO (facet) Active Human Model (used in passive state, since it are PMHS tests)
Development of Active Human Model

Second step: Predict passive as well as active behaviour

- Controlled hip position using leg muscles
- Controlled elbow position using arm muscles
- Controlled head position using neck muscles + balanced muscle recruitment (based on Nemirovsky & van Rooij 2010)
- Controlled spine position using actuators (based on Cappon et al. 2007)

Facet pedestrian human model MADYMO v7.4
Capabilities of Active Human Model

- Newly released MADYMO 50%ile male Active Human Model
  - Simulates pedestrian as well as occupant impacts
  - Simulates only passive or passive + active (=live) behaviour
  - Simulates stabilising behaviour in seating position automatically

- ‘Active’ via the usage of controlled activated:
  - Muscles in neck / arms / legs to stabilise head / elbows / hips
  - Actuators on vertebral joints to stabilise spine
  - For neck muscles co-contraction can be defined (= the simultaneous tension of all muscles without giving any resultant torques, in reality co-contraction is always there in some extent)

- AHM can be set to 2 different states:
  - ‘Live’: the human is stabilising to its initial position or user defined position
  - ‘Passive’: no stabilisation takes place and the human behaves as a post mortem human subject
WSU test: \( v = 6.7 \text{ m/s} \)

Active Human Model

WorldSID Model
Simulation results versus Test results

Graphs showing the comparison between Simulation results and Test results for two different systems labeled as Non-imp. shoulder y-displacement and I y-displacement. The graphs display the change in displacement over time (in ms) for AHM Model, WS Model, and Test result.
Contact forces are measured at the shoulder bar and the thorax bar of the sled separately.
WSU test: $v = 9.1 \text{ m/s}$
Simulation results versus Test results
Shoulder + thorax contact force [N]

Time [ms]

-5000 0 5000 10000 15000

0 10 20 30 40 50 60

AHM Model
WS Model
Test result
Step 2: Parameter variations in side impact

Objective:

• Investigate the effect of the seating height in comparison to other possible parameter variations

• By means of simulations with MADYMO (facet) WorldSID and MADYMO (facet) Active Human Model with parameter variations
• Simulation model is based on crash test with the AE-MDB side-impact barrier (APROSY)

• F063401_Cam01.AVI
• F063401_Cam04.AVI
WorldSID Side Impact simulation

- WorldSID simulation model:
  - General facet seat model
  - FE lapbelt
  - Ellipsoid door model with arm rest
  - Ellipsoid airbag

Output:
- Shoulder force
- Shoulder deflection
- Chest deflection (max of 3 ribs)
- VC (max of ribs and shoulder)
Standard simulation WorldSID
• Simulation model variations:
  • Seat height
• Simulation model variations:
  • Lateral arm rest position

- 30 mm  Normal  + 30 mm
• Simulation model variations:
  • Door deformation

![Simulation model variations with door deformation variations: normal, +10%, -10%, +10%](image)
## WorldSID results

<table>
<thead>
<tr>
<th>Simulation</th>
<th>Maximum injury values</th>
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<td>Seat height</td>
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Preliminary conclusions WorldSID simulations

- Seat height -100 mm
  - Most severe shoulder deflection and force → full shoulder impact
  - Most severe chest deflection → armrest impacts close to chest
- Seat height normal
  - Less severe shoulder deflection and shoulder force → shoulder above door
- Door deformation up +10%
  - Higher shoulder force → more severe impact of shoulder

Seat height: -100 mm
Door deformation: up +10%
Active Human Model Side Impact simulation

• Active Human Model simulation model:
  • General facet seat model
  • FE lapbelt
  • Ellipsoid door model with arm rest
  • Ellipsoid airbag

Output (equal to WorldSID):
• Acronium force
• Acronium deflection
• Chest deflection (max of 3 ribs)
• VC (max of ribs and shoulder)
Standard simulation Active Human Model
## Results Active Human Model

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<tr>
<td>Seat height</td>
<td>75.6</td>
<td>21.1</td>
<td>96.8</td>
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<tr>
<td>Arm rest displacement</td>
<td>57.6</td>
<td>5.4</td>
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<td>Door deformation</td>
<td>1796.2</td>
<td>544.7</td>
<td>2340.9</td>
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<td>Shoulder Rib Deflection [mm]</td>
<td>0.9</td>
<td>0.2</td>
<td>1.1</td>
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</table>
Preliminary conclusions Active Human Model

- Seat height -100 mm
  - Most severe shoulder deflection and shoulder force → Full shoulder impact
- Seat height normal
  - Most severe chest deflection → Upper part of door impacts chest
  - Low shoulder deflection and forces → Shoulder above door
- General
  - In case of seat height variations: when shoulder deflection is higher, chest deflection is lower and vice versa.

Seat height: -100 mm
Door deformation: up +10%
Conclusions

• Comparison WorldSID and Active Human Model in WSU tests:
  • Generally the WorldSID and Active Human Model kinematics are comparable to each other as well as to the human subjects responses

• WorldSID side impact simulations:
  • Seat height has a significant effect on shoulder deflection and force
  • Door design influences chest deflection

• Active Human model simulations:
  • Seat height has a significant effect on shoulder deflection and force
  • Seat height variation:
    • Shoulder deflection higher → Chest deflection lower and vice versa

• Difference WorldSID versus Active Human model
  • Chest and shoulder deflection are generally higher for Active Human Model
  • Shoulder force is generally higher for WorldSID
  • Chest deflection shows more variation for WorldSID
    • WorldSID seems more sensitive for door design variation