Modifications to the THOR-50M for Improved Usability in Reclined Postures – Update and Preliminary Findings

NHTSA Contract No. DTNH2215D00022/693JJ919F000222

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SAE Government Industry Meeting – Feb. 2021

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THOR 50M in Reclined Postures

- Prasad et al. 2019 (GIM)
  - Positioning / usability study with THOR, H3, other dummies
  - 2012 Odyssey Driver’s seat
  - THOR was able to recline
  - Concerns for gaps in abdomen, deformation in lumbar spine

- Goals for this study
  - Expand positioning study to other seats
  - Identify potential limitations / concerns
  - Develop & prototype potential parts modifications to improve usability in recline
  - Implement modifications in NHTSA’s THOR FE model
Positioning Study – Qualitative Analysis

- 2018 Honda Odyssey 2nd row captain’s chair
- Acura TLX Driver’s Chair
- LAB seat with marionette positioning
Lumbar flex joint pulls apart under extension

Amount of extension depends on seat geometry

Report: NHTSA BioDB TSTNO 12990
Positioning Study – Key Findings

Generic Seat

Pelvis Flesh
Restricts Hip Extension

Low-Pivot Point

Lifts Thighs from Seats

Report: NHTSA BioDB TSTNO 12990
Positioning Study – Key Findings

Substantial Gaps in Jacket, Flesh, Abdomen

Jacket Limits Recline, Shunts Loads/Moments Around Spine

Report: NHTSA BioDB TSTNO 12990
Design Goals

Increase range of motion of hip extension

Minimize jacket/abdomen gaps throughout range of motion

Increase range of spine motion without damaging lumbar flex joint

New lower thoracic flex joint

Do not adversely affect biofidelity in upright postures

1-piece honeycomb abdomen
Updated Jacket
Design Goals

Increase range of motion of hip extension

Minimize jacket/abdomen gaps throughout range of motion

Increase range of spine motion without damaging lumbar flex joint

Do not adversely affect biofidelity in upright postures

Modified hip & thigh flesh

New lower thoracic flex joint

1-piece honeycomb abdomen

Updated Jacket
New Lower Thoracic Spine Flex Joint

Base: publicly-available NHTSA THOR FE Model

Goal: Distribute flexibility within the spine
New Lower Thoracic Spine Flex Joint

Base: publicly-available NHTSA THOR FE Model

Goal: Distribute flexibility within the spine
Goal: Greater range of hip extension
Modified Pelvis & Thigh Flesh

Goal: Greater range of hip extension
Slight difference in initial positioning due to bending of the new upper lumbar flex joint during gravity settling. NHTSA certification corridors provided where applicable.
Preliminary Results

Gold Standard 1

Stock THOR
Lower Thorax Flex Joint + New Pelvis Flesh

40 km/h, No Force Limiter
Preliminary Results

Gold Standard 1

Stock THOR
Lower Thorax Flex Joint + New Pelvis Flesh

40 km/h, No Force Limiter
Gold Standard 1 Cut View

Lower Thorax Flex Joint (LTFJ)
Lumbar Flex Joint (LFJ)
Preliminary Results

Gold Standard 1 Cut View

40 km/h, No Force Limiter

Kinematic Plot

X Displacement (mm)

Lower Thorax Flex Joint (LTFJ)

Lumbar Flex Joint (LFJ)
Preliminary Results

Reclined

Test Environment: Richardson et al. 2019 ESV, 2020 Stapp

Stock THOR
Lower Thorax Flex Joint + New Pelvis Flesh
Preliminary Results

Reclined Cut View

Test Environment: Richardson et al. 2019 ESV, 2020 Stapp
Preliminary Results

Pelvis Motion

Stock THOR

Modified THOR (Lower Thorax Flex Joint + New Pelvis Flesh)

Pelvis Rotation

Dashed Lines: PMHS corridors from Richardson et al. 2020 Stapp.
Preliminary Results

Pelvis Sensitivity Study

Lower Thorax Flex Joint + New Pelvis Flesh

Coxal Bone Material Replaced with Soft Material

Pelvis Rotation

Dashed Lines: PMHS corridors from Richardson et al. 2020 Stapp.

Stock THOR
Modified
Coxal Bone Mat. Replaced with Soft Material
Pelvis Stiffness x5
Pelvis Stiffness x10
Pelvis Stiffness x100
Pelvis Sensitivity Study: Lumbar LC

Preliminary Results

Lumbar LC Y Moments

Lumbar LC Z Force

Stock THOR
Modified
Coxal Bone Mat. Replaced with Soft Material

Pelvis Sensitivity Study: Lumbar LC

Lumbar LC Y Moments

Lumbar LC Z Force

Stock THOR
Modified
Pelvis Stiffness x5
Pelvis Stiffness x10
Pelvis Stiffness x100
Next Steps

- Unified abdomen design & modeling
- Prototype fabrication
  - Lower thorax flex joint
  - New pelvis & thigh flesh
  - Unified abdomen
  - Modified jacket
- Certification testing
- Final positioning assessment
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Questions?
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Thank You!

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