NHTSA's Child Side Impact Protection Research Program

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Research

- Initial Validation of Sled Concept
- Evaluation of "Door" Padding Stiffness
- Initial Testing of Rear-facing Restraints and Seat Cushion Foams
- Evaluation of Q3s Dummy

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Initial Validation of Sled Concept

- **Conducted sled tests**
  - Based on Takata's sliding seat with "intruding door" procedure
    - NHTSA made some modifications to test set-up
  - Phase I – Tests at 0° and 10° impact angle; 5 different CRS models
  - Phase II – Tests at 15° and 20° impact angle; selected 3 of previous 5 CRS models tested

- **Conducted four (4) side impact crash tests**
  - Based on FMVSS No. 214 procedure

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Summary of Initial Testing

- **Sled provides good replication of side impact crash**
  - Sled and crashed vehicle responses comparable
- **Dummy and CRS kinematics in sled tests similar to those in crash tests**
  - Armrest issue needs further investigation
  - Additional evaluation of results required to refine side impact sled test parameters
- **Previously presented at 2008 and 2009 SAE Government Industry meetings**

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Research

- Initial Validation of Sled Concept
- Evaluation of "Door" Padding Stiffness
  - Three different stiffnesses of padding
  - Potential armrest design
- Initial Testing of Rear-facing Restraints and Seat Cushion Foams
- Evaluation of Q3s Dummy

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Free Motion Headform (FMH) Tests

- **Used pedestrian GTR 3.5 kg child headform at 24 kph**
- **8 vehicles tested**
  - Nissan Sentra, Nissan Versa, Volvo XC90, Chevy Trailblazer, Toyota Highlander, Infiniti FX35, Nissan Pathfinder, Dodge Caravan
    - Door padding
    - Armrest
- **Side impact sled buck (i.e. rigid wall)**
  - Foams with varying stiffness and thickness

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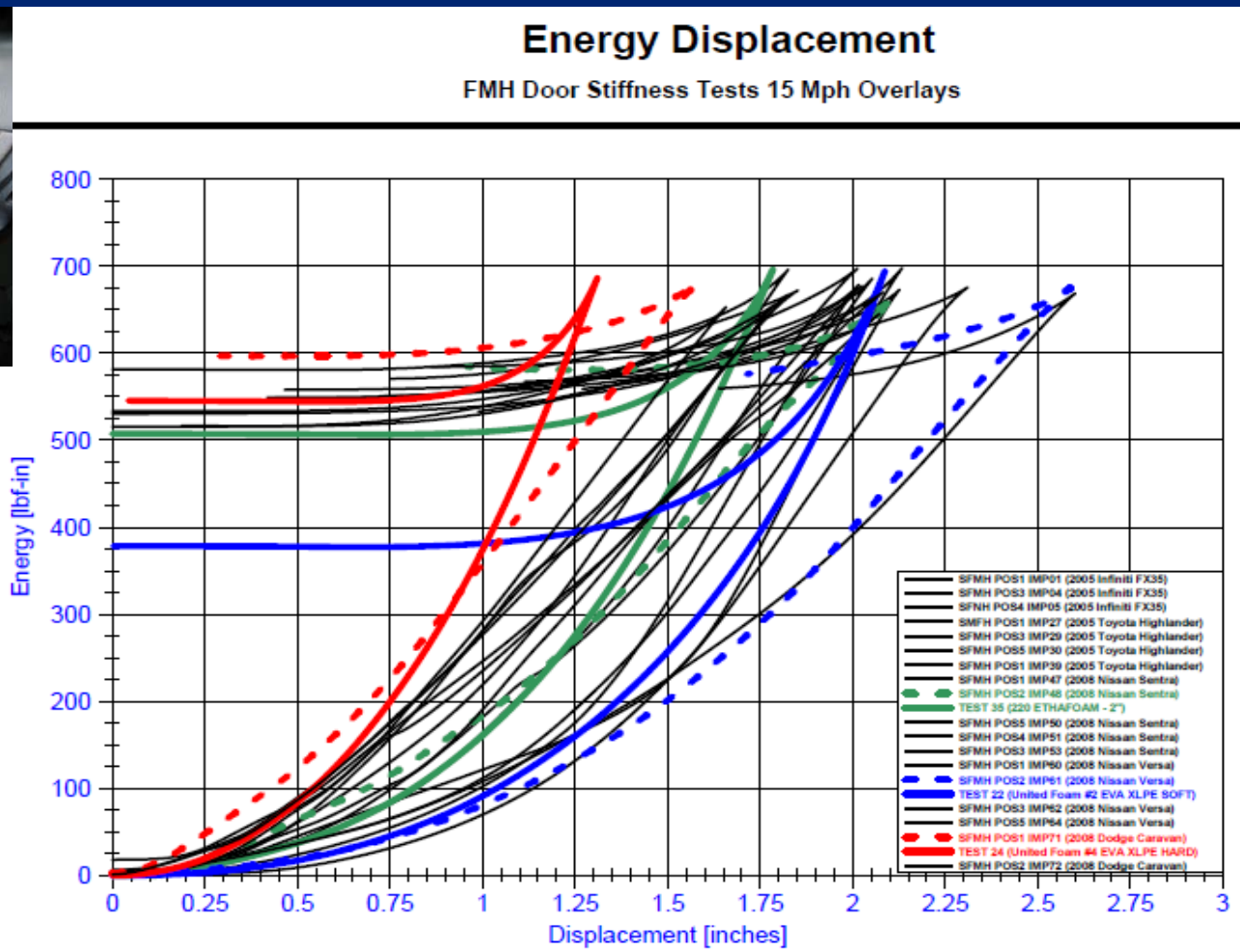
FMH Door Testing

Dashed colored curves – vehicle interior door results

Solid colored curves – foam materials selected for use in sled tests



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Sled Tests to Evaluate "Door" Padding Effect

- **Angle of 10° selected for test buck**
  - Based on crash test results and accident data analyses
- **Evaluated "stiff", "average" and "soft" foams at 5 cm (2") thickness**
  - Tested with CRS models used during crash tests
    - Graco SafeSeat Step 2
      (renamed to Graco Cozy Cline in 2009)
    - Maxi-Cosi Priori

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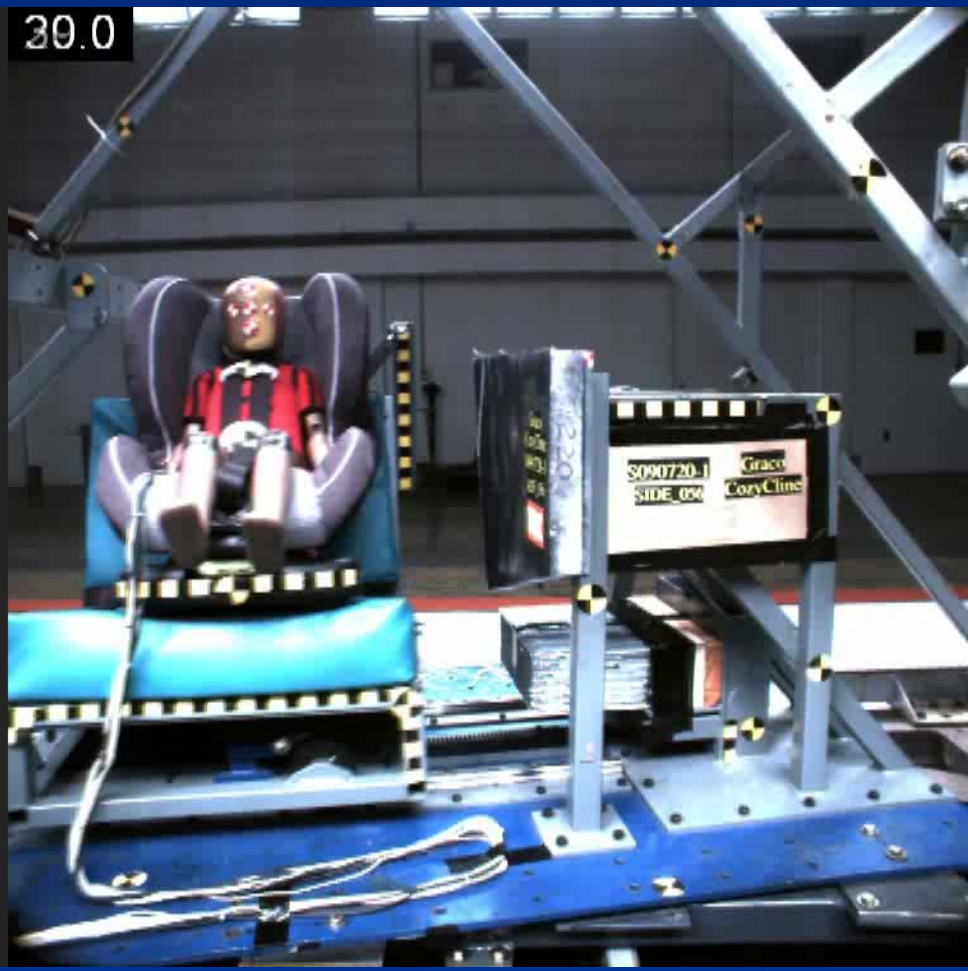
Sled without Armrest
SafeSeat Step 2 (Cozy Cline)
Frontal Videos



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Armrest Design

Armrest

5 cm (2.5”) thickness over lower portion of “door” – used “average” foam material

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Initial Sled Tests to Investigate "Armrest"

- **Conducted 2 tests of each dummy / CRS configuration**
  - **Forward facing with Q3s dummy**
    - **tested 3 CRS models used in previous series**
  - **Rear-facing with CRABI 12 month dummy**
    - **1 convertible (Maxi-Cosi Priori)**
    - **2 infant only with detachable base (Graco SnugRide and Chicco KeyFit30)**

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Sentra Crash vs Sled with Armrest Graco SafeSeat Step 2 (Cozy Cline)

Frontal Videos

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Research

- Initial Validation of Sled Concept
- Evaluation of "Door" Padding Stiffness
- **Initial Testing of Rear-facing Restraints and Seat Cushion Foams**
  - **1 convertible CRS**
  - **2 infant only CRS**
  - **FMVSS 213 and ECE R44 seat foams**
- Evaluation of Q3s Dummy

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Rear-facing CRS Tests

Maxi-Cosi Priori

Graco SnugRide

Chicco KeyFit30

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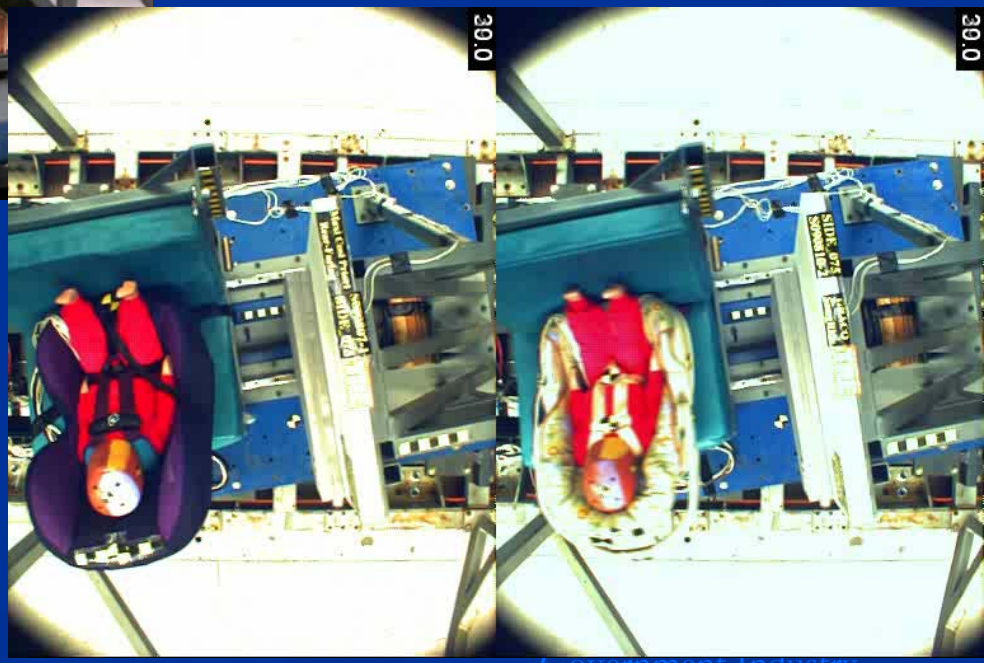
RF Convertible vs RF Infant Only

Frontal and Overhead Videos

Graco SnugRide Infant with Base on Right



Maxi-Cosi Priori Convertible on Left

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FMVSS 213 and ECE R44 Seat Cushion Comparison

- **FMVSS 213 seat cushion is soft compared to ECE R44 seat cushion**
- **Forward facing with Q3s dummy**
  - **3 CRS models used in previous series**
- **Rear-facing with CRABI 12 month dummy**
  - **1 infant only with detachable base (Graco SnugRide)**

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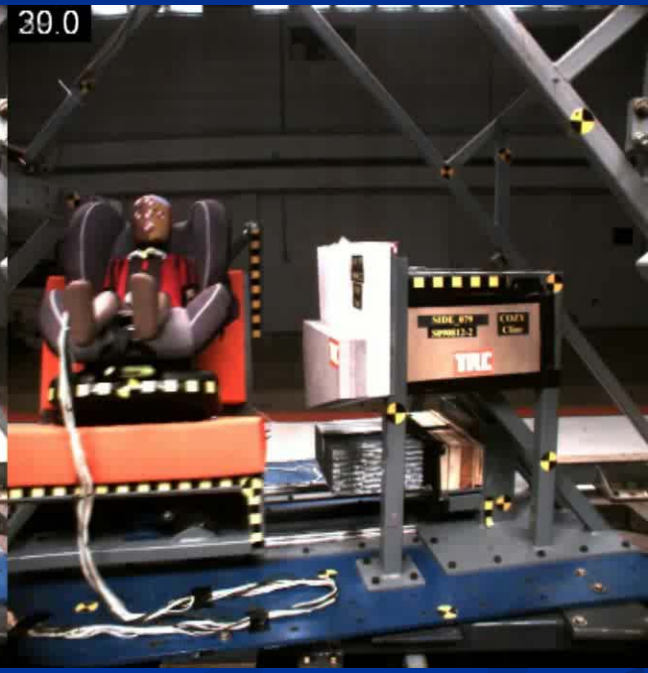
Comparison of FMVSS 213 & ECE R44 Cushions with Q3s in FF CRS

Frontal Videos

Sentra Crash Test

FMVSS 213 Seat Cushion



ECE R44 Seat Cushion

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Summary of Results

- **Buck angle of 10° provides good replication of dummy / CRS kinematics observed in crash tests**
- **Based on dummy head and neck injury responses**
  - **Stiffness of "door" padding does not appear to have pronounced effect (based on limited # of tests)**
- **More research required to assess**
  - **need for armrest**
  - **effect of sliding seat cushion stiffness on results (including NPACS proposed seat foam)**
- **Conduct fleet tests using majority of CRS models sold in U.S.**

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Research

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- Evaluation of "Door" Padding Stiffness
- Initial Testing of Rear-facing Restraints and Seat Cushion Foams
- **Evaluation of Q3s Dummy**

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Evaluation of Q3s Dummy

- **During the preliminary evaluation of the Q3s dummy, VRTC identified three primary issues:**
  - **Thorax Durability**
  - **Neck Biofidelity**
  - **Pelvis/Femur Design**

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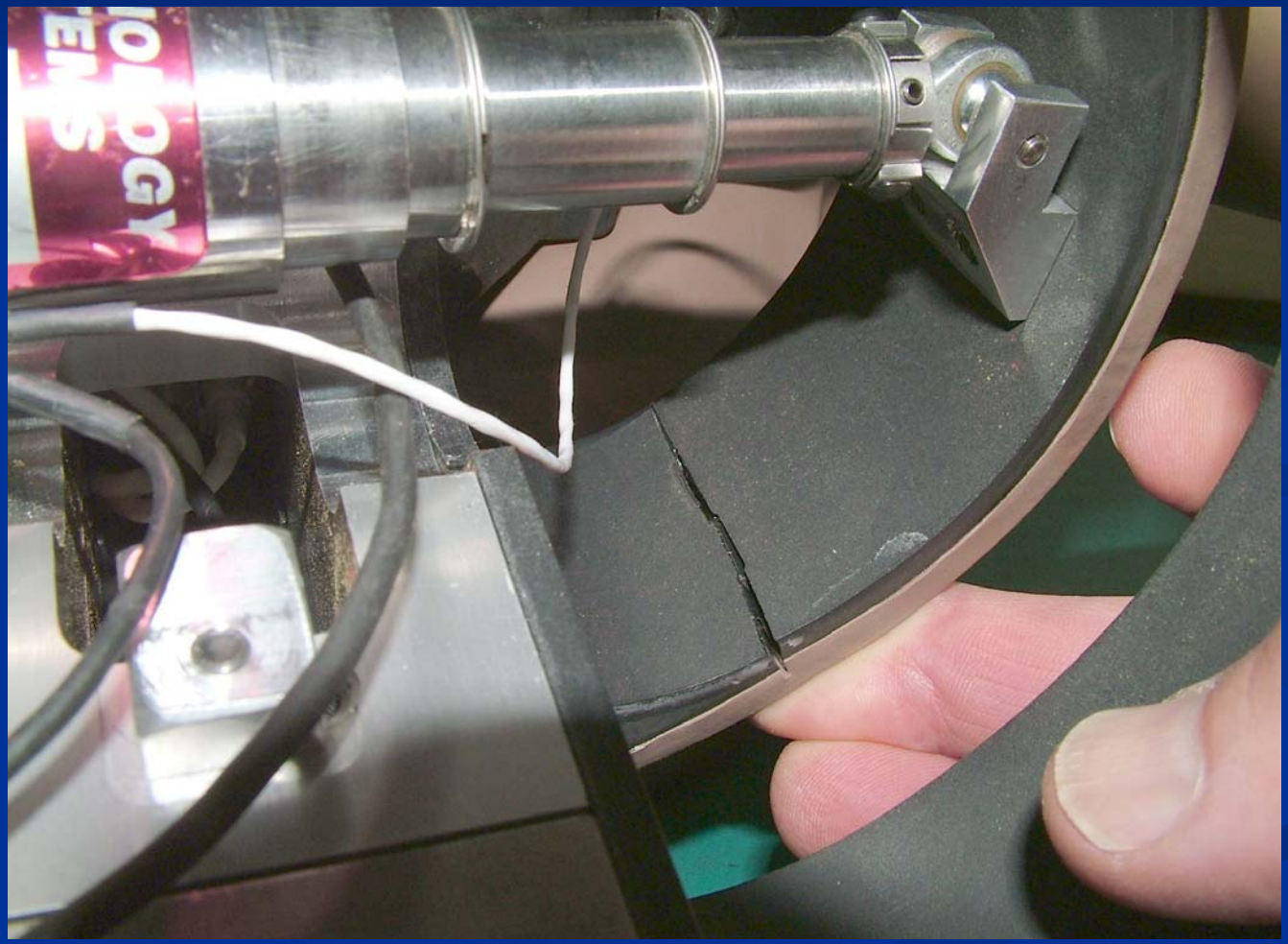
Thorax Failures



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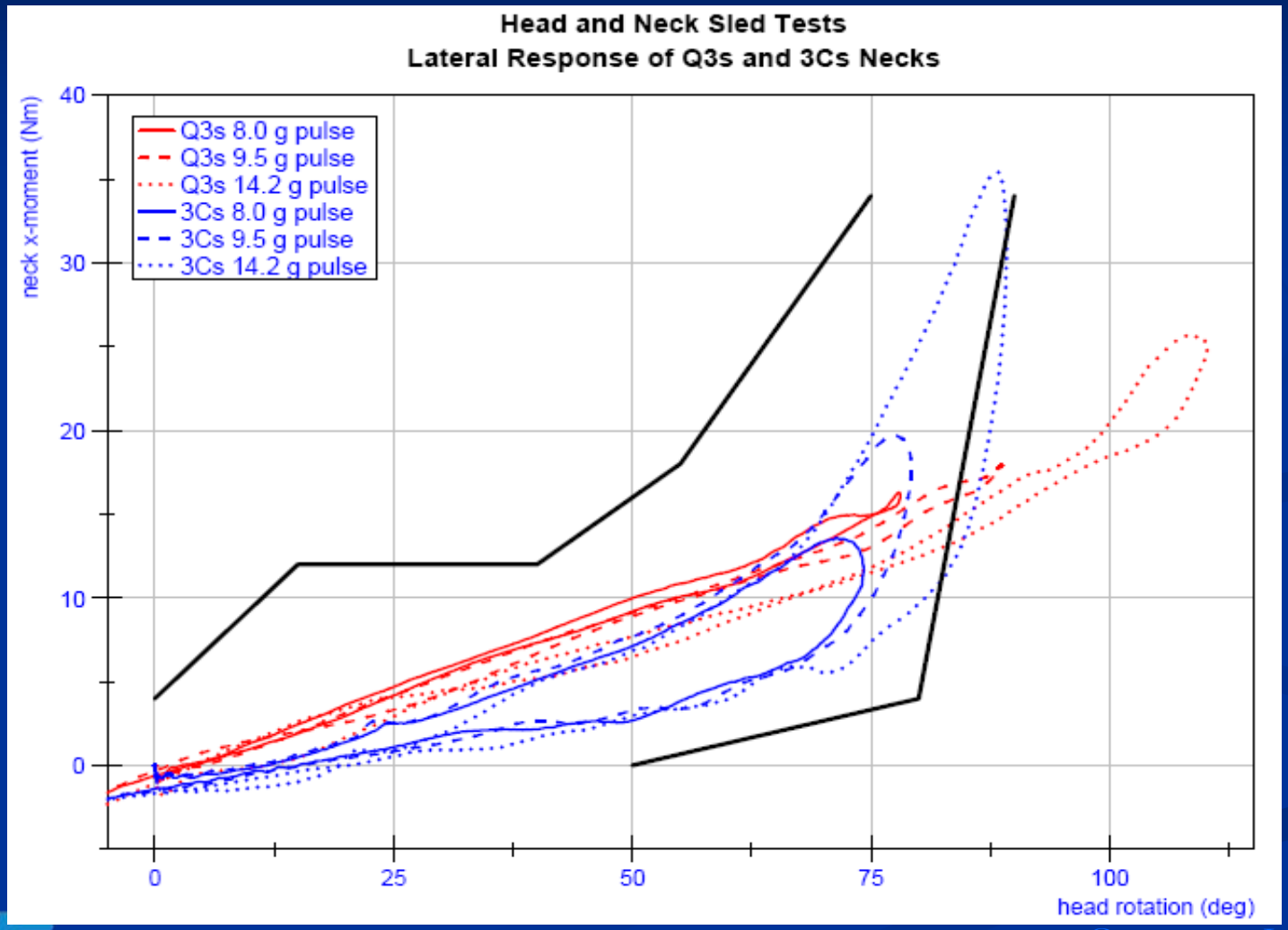
Neck Biofidelity



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Pelvis/Femur Issues

Femur fill material was incompatible with vinyl skin and would not fully cure

Femur ball could dislodge from hip socket resulting in leg separation from torso

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Q3s Design Revisions

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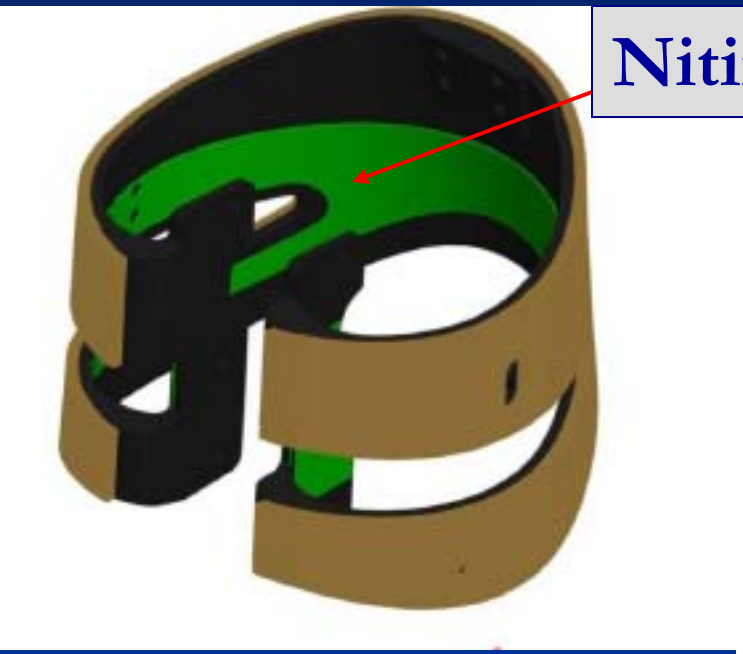
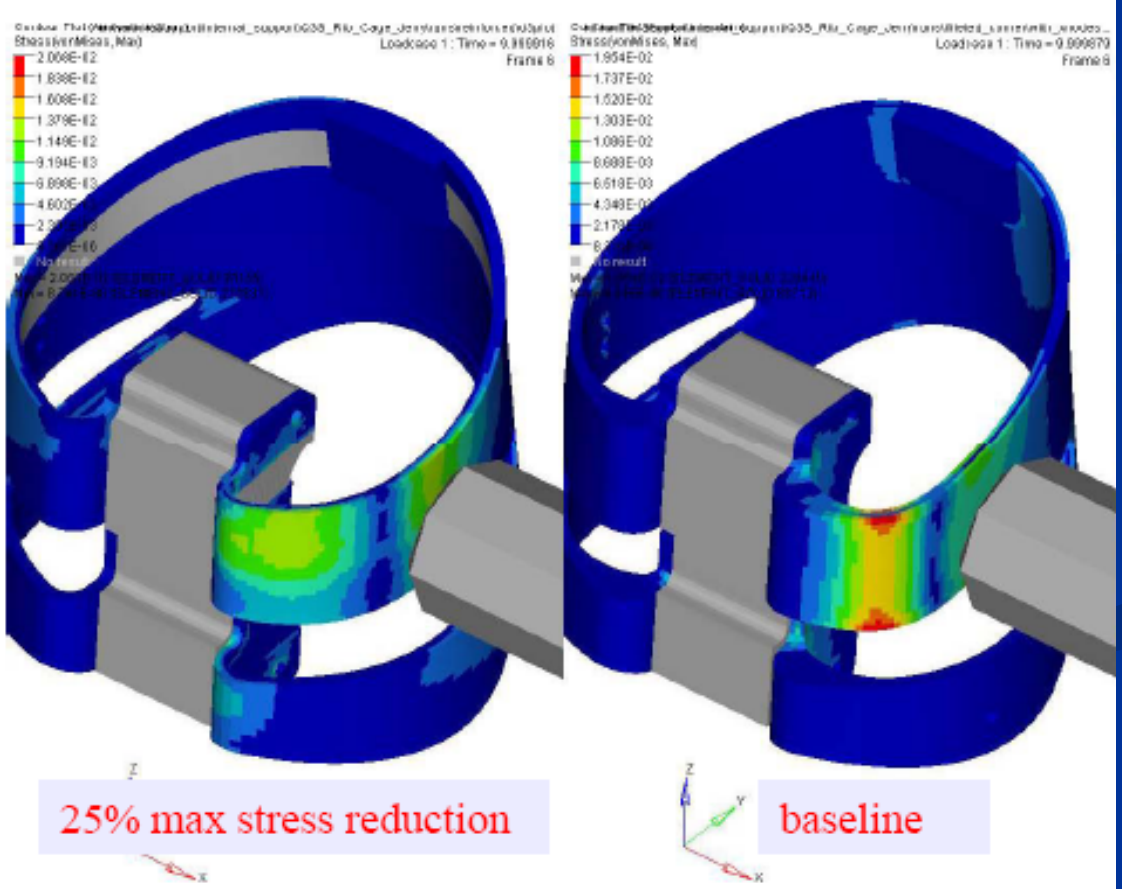
Thorax Modifications



FE Stress Analysis

Reinforced Nitinol design

Filleted corner design



Images courtesy of FTSS

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Evaluation of Nitinol Rib Vers.3

- **100 "Standard" Thorax Impacts**
  - 3.8 kg probe
  - 3.3 m/s impact speed
  - Bench seat
  - Impact to lateral thorax at IR-Tracc mounting location
  - Impact-side arm removed
- **10 High Severity Impacts**
  - Same as above except 3.8 m/s impact speed

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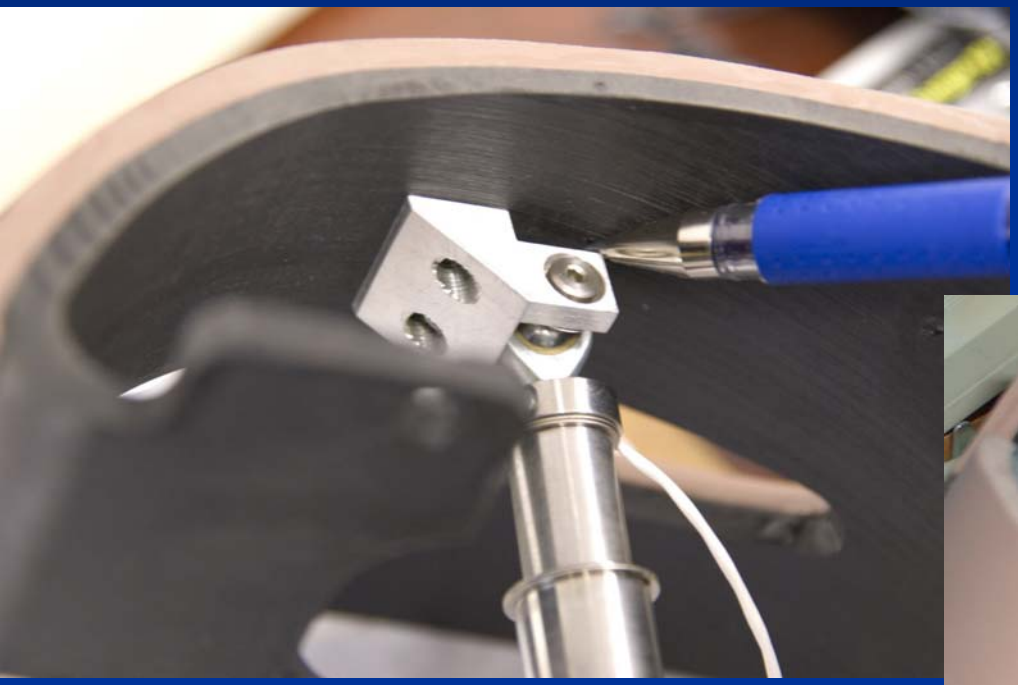
IR-Tracc Bracket Contact



FTSS plans to modify bracket

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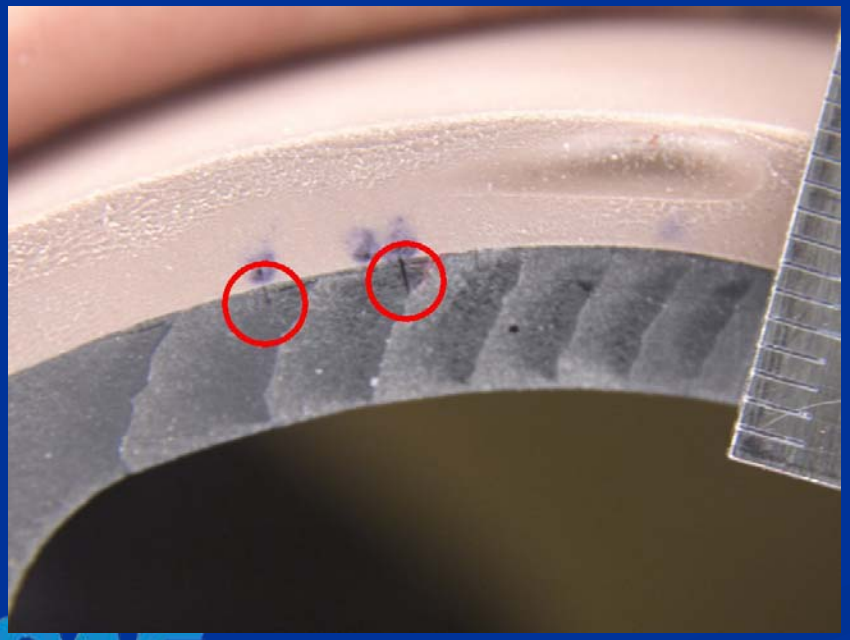
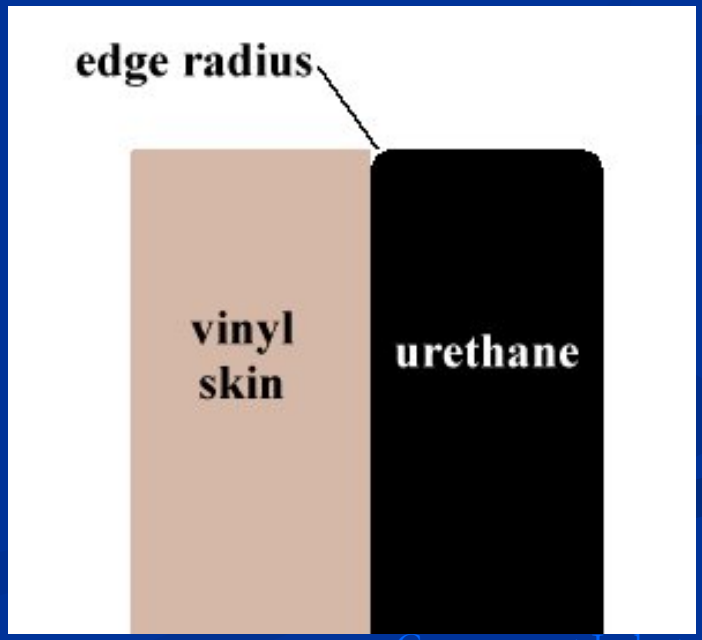
Micro-cracking in Urethane

- First observed after test # 67
- Minor propagation after initial observation
- Final crack length ~ 1.2 mm
- FTSS proposes to introduce an edge radius to eliminate stress riser in the urethane





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Summary of Rib Modifications

- Durability improved significantly
- Repeatability of responses was excellent
- Minor design issues to be addressed
  - Modify IR-Tracc bracket
  - Add edge radius to urethane
- Minimal permanent deformation observed
- Additional pendulum and sled testing planned to assess durability and biofidelity

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Neck Revision

- New Q3s neck based on 3Cs design, which VRTC developed with Denton ATD
- Preliminary results are encouraging
- Continuing to refine the design

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Pelvis/Femur Revisions

- New upper leg filler material is compatible with vinyl flesh
- Aluminum hip cup and hardened femoral ball improve femur retention

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