Development of a Surrogate Seatbelt Retractor for Use in Child Restraint Testing

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Booster Seats in the Field

- Booster seats are used in the field with vehicle production 3-point belts that have shoulder belt retractor systems.
- Retractor systems spool small amounts of webbing out during a crash event:
  - some at initial lock up
  - some due to tightening of webbing spool
  - potentially with load limiting
Booster Seats in the Lab

• FMVSS No. 213 evaluates booster seat dynamic performance using a static 3-point belt with no spool out

• Booster seat designs could be improved if tested using more realistic belt systems

• Why not use real retractors?
  – Expense
  – Variation among manufacturers
  – Repeatability
Objectives

Develop hardware and procedures for a surrogate seatbelt retractor for potential use with dynamic evaluation of belt-positioning booster seats
Commercial Hardware Survey

- Measured convenience sample of 20+ UMTRI staff vehicles
- Phone survey of manufacturers
- Determined resting belt tension
- Determined amount of spoolout with belt jerk
- Established targets of 1-2 inches of spool out and 2-4 lbf resting tension
Surrogate retractor

- Resting tension of 9-14 N
- Spoolout can be adjusted to different levels
Test bench

- Drawings from May 17, 2015
  Federal Docket No. NHTSA-2013-0055-0002
- Lower anchors lowered 40 mm
- Back extended upwards 50 mm
- Midway through testing, shoulder belt anchor moved inboard according to the drawings posted in docket NHTSA-2013-0055-0008 (Aug. 25, 2015)
Vehicle Seats

- Kinematics depend on
  - Vehicle seat stiffness
  - Belt anchor geometry
  - Retractor

- Vehicle systems
  - Ford Explorer
  - Jeep Grand Cherokee
ATD and Instrumentation

• Hybrid III 6YO ATD
• Instrumentation
  – Head, chest, pelvis triaxial accelerometers
  – Load cells in upper neck, lower neck, lumbar spine, upper and lower ASIS
  – Angular rate sensors in spine and pelvis to measure rotation about y-axis
• Current FMVSS No. 213 seating procedures
CRS Selection

B1: Graco Turbobooster
B2: Evenflo AMP
B3: Safety 1st Incognito
B4: Bubble Bum Inflatable
## Sled Test Matrix

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<th>B2</th>
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Series 1: several tests damaged ATD because of error in shoulder belt anchor location

Series 2: testing run using shoulder belt location included in August 2015 drawing revision that resolved error
Static vs Production on Vehicle Seats
(3 comparisons – 6 tests)

Static Belt produces:
- Higher HIC (up 85), Neck Force (up 148 N)
- Lower Torso Angle (down 20 deg), Head Ex (down 55 mm), Knee Ex (16 mm)
Vehicle Seats vs. Test Bench

- Compare kinematics between vehicle seat and test bench
  - Static belts
  - Production belts
  - Using same booster
- Preliminary 213 test bench kinematics closer to tests run with Ford seat than Jeep seat
- Design of surrogate retractor tuned to match Ford retractor
Comparison of surrogate vs production

Surrogate Belt produces kinematics similar to production belt:
- Lower HIC (down 11), Neck Force (down 148 N)
- Lower Torso Angle (down 2 deg),
  Head Ex (down 12 mm), Knee Ex (15 mm)
Comparison of surrogate vs production
Comparison of surrogate v production – Booster 1

*Legend will be added & plot lines better distinguishable*
Summary and Continuing Research

• Surrogate retractor produces realistic kinematics compared to production belts
• Assess surrogate retractor performance with a greater range of booster seats, including high back boosters
• Assess durability of surrogate retractor using Hybrid III 10YO
• Assess repeatability of surrogate retractor
We acknowledge the National Highway Traffic Safety Administration for sponsoring this research.

Thank you for your attention.